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APPLIED MECHANICS REVIEWS

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# ELECTROANALOGIC METHODS

## *III. Solution of problems by d-c resistance-network procedures*

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PARTS I and II of this article [See AMR, January and February 1956] respectively comprise an account of electroanalogic solution by continuous-type conductive (tank, plate, sheet or liquid surface) procedures of problems of electric and magnetic nature (1-111)[1] and of continuum-mechanics (elastic, thermic, hydrodynamic, and aerodynamic) nature (112-314). This part III encompasses account of solution of like problems by the discrete-type conductive procedures afforded by d-c resistance networks.

### 17. GENERAL BASES

The general bases, broad applicability, international use, and general power of analogic solution by d-c resistance networks are well-detailed in general writings by Soroka (1,2), Peres and Malavard (4,5), Germain (6,315) and Paschkis (316). Herein, it is evidenced that a resistance network commonly affords approximate, rather than exact, solution of a problem under consideration—for the basic procedure hinges on approximating the actual differential equations and boundary conditions describing the given problem by corresponding difference equations and associated boundary conditions and effecting analogic solution of the resulting "equivalent" problem.

Although, as evidenced in later references, d-c resistance-network analogic solution was in limited use in the 1920's and 1930's—principally for power-system studies—common and international usage for solution of problems in various domains of science and engineering came in the 1940's, as sparked by the writings of Gutenmacher (317), Hogan (318), Redshaw (319), Kron (320), Peterson and Concordia (321), DePackh (322), and others. In the 1950's, before his recent death (323), G. Liebmann made remarkable advances in the design and use of high-precision d-c resistor networks, as summarized in successive general papers (324-326). Specifically, a precision of 1 part in 10,000, and even better under very favorable conditions, was achieved by statistical cancellation of resistor errors (324), use of low-tolerance wire-wound resistors, reduction of mesh errors by use of extrapolation methods based on Richardson's method of deferred approach to the limit (325,327), a precisely worked-out use of unequal-sized meshes (328, 329), and other techniques of refinement.

Yet other aspects of improvement in accuracy of solution are encompassed in the writings of Persico (330), who stresses the utility of additional diagonal resistors in conjunction with the basic square mesh to obtain greater accuracy than in the original networks used by Liebmann and DePackh; of MacNeal's (331) and Tasny-Tschiassny's (332, 333) investigations of mesh variation which enable marked improvement in network solutions of problems encompassing anisotropic media, thus tensor conductivities; of Huard de la Marre (334) on improvement of accuracy by better satisfaction of conditions along a curved boundary; and by various procedures encompassed in a very considerable (but hard to obtain!) body of Russian work, such as evidenced in the papers by Bykhovshii (335) and Shura-Bura (336).

Finally, the unique cathode-ray apparatus developed by Liebmann and Bailey (337), which affords semi-automized speedy visual display of error reduction, merits especial mention.

### 18. POWER-SYSTEM ANALYSIS

As noted in the opening paragraphs, the first extensive use of d-c resistance networks was for power-system analysis, particularly under unbalanced conditions (321, 338). For such purpose the early d-c resistance boards (338-342), lacking means of encompassing phase differences, were superseded for accurate general studies by a-c impedance-network analyzers (321, 343). However, for many purposes, the less complicated, and much less expensive, d-c board yet suffices when utilized with artifices such as the two-network method suggested by Hahn (344), the four-circuit procedure developed by Enns (345, 346), the modification of Hahn's method suggested by the London Division of the Central Electricity Authority, and the recent two-phase supply procedure advanced by Field (347). Accordingly, over the years, d-c boards have been continuously improved (348-352) to the end that modern d-c boards still play an important role in power-system studies (353-357).

[1] Numbers in parentheses indicate references at the ends of parts I, II and III.

## 19. WATER, GAS, AND STEAM DISTRIBUTION

Use of d-c linear-resistance boards for power-system distribution studies suggest similar application for water-distribution networks. Although such is possible, the nonlinear relationship between head loss $H$ and rate of flow $Q$ of the moving material, namely $H = \text{Const } Q^a$ where $a \cong 1.85$, necessitates solution by repeated sequences of resistor settings and associated numerical computations [analogous to the gradual reduction of error in the Hardy-Cross numerical method suggesting such approach (358)] for both the direct (359–364) or modified (365) analogies. A similar procedure can be utilized for gas-distribution studies (366, 367). Such fact naturally suggests design of d-c boards employing suitable nonlinear resistors whereof the voltage drop $V$ varies with the current $I$ as $V = \text{Const } I^a$.

Initial, increasingly successful efforts at MIT making use of commercial vacuum tubes and tungsten filaments as the nonlinear element (368–371) culminated in the McIlroy analyzer employing low-voltage specially-designed tungsten filaments supported on heavy nickel leads in evacuated glass bulbs (372, 373). This analyzer, now commercially manufactured by the Standard Electric Time Company (374, 375), affords ready solution of hydraulic (374–378), gas (379), and steam (380) distribution systems.

Recently, de Brem (381) has described a linear resistor network wherein the hand-regulated resistors are rapidly brought to the correct values through the aid of an oscillographic display, whereby bringing the spot on to a reference curve corresponding to the properly chosen index $a(\cong 1.82$ for gas) both obviates tedious numerical corrective calculation and yields (it is claimed) greater accuracy than in the current-variable resistor approach.

## 20. MAGNETIC AND ELECTRIC PROBLEMS

Koenig (382) has advanced an interesting analog whereby the equivalent d-c resistance network analogs magnetic fields produced by static current-carrying conductors, flux being represented by current and magnetic potential difference by electric potential difference effected through suitably inserted batteries. This analog is used to analyze magnetic circuits enfolding saturable magnetic material, as in the magnetic circuit of a salient-pole synchronous machine.

Study of the determination of magnetic-flux leakage effects in electrical machines caused by the ventilating ducts of the rotor or the coil slots in rotor and stator is an old problem, studied by F. W. Carter in 1912 by use of conformal mapping. This is of particular pertinent interest in connection with the mechanical centering stability of the rotor, especially when a small oscillation is deliberately introduced about a stable position. Determination of the restoring force hinges on knowledge of the average flux density $B(x)$ for the slot displacement $x$ and of $dB/dx$, accurate computation of which was more or less intractable to Carter because of the elliptic functions involved. Accurate resistance-network determination of these values for a number of cases covering the range of greatest interest in practice has recently been effected by Leibmann (383).

Finally, Bridoux and Lafleur (384) have used resistance networks to determine the phase and amplitude characteristics of transfer functions, thus complementing earlier determinations by continuous conductive procedures (66, 67).

## 21. ELECTROSTATIC AND MAGNETOSTATIC ELECTRON-OPTICS SYSTEMS

Investigation of electrostatic and magnetostatic problems associated with axially symmetric fields such as occur in the design of electron-optics systems can easily be effected by resistance networks constructed on a polar coordinate basis. That such involves resistors graded in magnitude radially and, often, axially causes no particular construction difficulties. By such means Liebmann (385–389) has effected a series of studies of, mainly, rotationally symmetric systems enabling marked improvement in electron microscope optics design through minimization of spherical aberation, increased efficacy of pole structure, and other means. Recently, the National Bureau of Standards (390) has constructed a precision polar-coordinate network specifically for electron-optics investigations, though it can be used for other investigations, such as resonator design or heat and fluid-flow studies.

## 22. CAVITY RESONATOR AND WAVE-GUIDE PROBLEMS

The first d-c resistance network enabling determination of the natural frequencies and mode-distribution values of cavity-resonators, wave-guides, and other wave-equation boundary-value problems was effected by Swenson and Higgins (391). For this, the required negative resistors are simulated by use of batteries connected through resistors between appropriate points. A later different approach by Liebmann (392, 393) comprises writing resistance-network technique with cyclic readjustment of currents fed into the network junctions. Excellent agreement between network-observed and theoretically calculated values of cutoff frequency, modal values, and field distributions of ridged wave guides, cavity resonators, and other shapes prove the validity and usefulness of both approaches.

## 23. ELASTICITY

Solution of elastic problems by resistance networks is excellently summarized in a recent paper by Liebmann (394). Such technique has been used by Benscoter and MacNeal (395) in the discrete torsional loading of a beam; by Hogan (318), Redshaw (319), Palmer (396), Gross and Soroka (397), and Renard (398) in the torsion of shafts; and by Malavard and Boscher (399) in the flexure of beams.

The critical, or buckling, load of rectangular beams has been investigated by Culver (400), using simple apparatus; of a nonuniform beam or column by Swenson (401), using the negative resistor board; and by yet another technique (cascaded networks) by Scanlon (402).

Plane stress problems can be described by the Airy stress function, which satisfies the biharmonic equation. Liebmann (402–406) has effected resistance-network solution of this problem by connecting two identical resistance networks in cascade by joining corresponding nodes in the two networks by (relatively) high-valued series resistors, feeding suitable currents in at the upper network, while applying appropriate boundary conditions at the upper network; and has exemplified solution by study of a square block loaded over part of its surface and a cross bar under tension. The mentioned series of papers comprises a most admirable investigation of the various factors affecting accuracy and evolution of preferred techniques.

A similar idea of cascaded networks was advanced earlier by Redshaw (407). A three-grid board (408) applied to determination of extension of a flat plate under a parabolic distribution of stress on opposite edges and of flexure of a plate by a uniformly-distributed load yields results in good agreement with calculated values. To achieve the improved accuracy afforded by use of fine meshes, Redshaw (409) recently described a more efficient construction of resistance network using a ribbon woven of Minalpha wire and silk.

A third independent construction based on use of two cascaded networks and its various application is encompassed in a series of papers by Malavard and/or Boscher (410–415), especial interest being focused on deflection of variously supported rectangular plates, both of homogeneous and variable thickness.

Gutenmacher (317) appears also to have utilized the basic idea of cascaded networks.

Determination of the natural frequencies, modal characteristics and similar vibrational problems of elastic bodies pose a more complex problem. Scanlan (402, 416, 417) has utilized the one-dimensional counterparts of the cascaded grid-network arrangements of Malavard and Boscher to obtain solution of numerous beam, column, and shaft eigenvalue problems, both in the elastic and plastic ranges. Again, by appropriate modification of the iteration procedure earlier utilized for electromagnetic eigenvalue problems (392, 393) in conjunction with cascaded resistance networks as used in solution of the biharmonic equation for plane stress problems (403, 404), Liebmann (418, 419) effected the eigenvalues and deflection values for a vibrating circular cylindrical clamped cantilever and for a "whirling" shaft with uneven mass distribution supported in three bearings, in excellent agreement with theoretically determined values.

In a somewhat unique approach, Berry (420) conjoins a rotating switch with resistance network to obtain critical loads on nonuniform columns; and Goran (421) has joined use of energy procedures and Lagrangian multipliers with resistance-network values to obtain load distribution on a skewed stiffened plate subjected to a uniform shear flow, as in stress analysis of a sweptback box beam having only rib ends, in good agreement with computed values.

## 24. HEAT TRANSFER AND RADIATION

The general bases of resistance-network solution of heat-transfer problems are delineated in an interesting article by McCann and Wilts (422). In a long series of papers, Kayan has utilized rather simple combinations of batteries and resistors to effect study of heat transfer and temperature distribution in or from finned bodies (423), panels with embedded tubes or structural elements (168, 424), composite wall structures between two heat-transferring fluids (425), heat exchangers and other heat-transfer equipment (426, 427), wet-bulb thermometer phenomena (428) and conjoined heat pump and refrigerating unit complexes (429–431). Enclosed-structure temperature distributions are also considered by Billington (423).

Interesting steady-state investigation of the cyclic de-icing of propellers (433) and of temperature distribution in cooled turbine blades (434, 435) evidences the utility of the grid-resistance-network approach, and indicates the values to be gained through being able to effect transient solutions by such, rather than by the more general impedance networks used heretofore. Liebmann has done precisely this, by uniting suitably designed resistance networks with successive readjustments of potentiometers supplying the network voltages, to obtain temperature distribution by conduction within externally heated bodies (436, 437). In later papers, the technique is extended to encompass problems of heat transfer across surfaces in nonuniform structures, generation or absorption of heat in the interior of a system, and latent heat effects (438, 439). Comparison of analog solutions with known theoretical solutions shows the rapidity, accuracy, and stability of the procedure; and solutions effected for structures complex in shape or physical composition attest to its considerable power and value in practice.

Liebmann's resistance-network approach could be utilized to effect numerical values for temperature rises in electrical machines, through the thermal network approach recently advanced by Bates and Tustin (440); and for the study of radiation heat transfer in electric furnaces, through the thermal network approach delineated by Paschkis (441) and, more recently and in greater generality, by Oppenheim (442–446).

## 25. FLUID FLOW

Problems of seepage, infiltration, and percolation, long studied by use of the electrolytic tank, are easily solved by resistance-network analogs. As yet, the body of published work is recent and limited, encompassing Luthin's (447) study of gravity draining in soils and Huard de la Marre's (448–450) admirable work on seepage through porous structures maintaining a free surface, as in earthen dams resting on solid substrata.

Again, the problems associated with material complexes such as occur in petroleum technology and conservation studies can, in some instances, be effected more easily on resistance networks than in electrolytic tanks. By such means Bruce (451, 452) and Schaefer (453) have gleaned insight to oil reservoir operations. More recently, Karplus (454–456) has studied water-coning phenomena through a conjunction of electronic computer and resistance network, whereof the first eliminates the need of successive sequences of trial adjustments and the second furnishes the desired precision.

Kettleborough's (185) earlier electrolytic-tank study of stepped-thrust bearing is complemented by his recent resistance-network investigation (457) and account of the relative merits of these two procedures for this problem. Similarly, the considerable volume of tank work on the cascade, or grids of blades, (236–247) is complemented by Concordia and Carter's (458) variable-resistor determination of fluid-flow patterns in an idealized two-dimensional centrifugal impeller.

## 26. AIRFOILS

The general values of resistance-network procedures in studying airfoil phenomena at both subsonic and supersonic speeds are well-evidenced in the general accounts by Malavard (262), Diprose (250), and Kuchemann and Redshaw (459); and in more detail by Poritsky, Sells and Danforth (460), who demonstrate their usefulness by solution of compressible fluid flow around a circular cylinder.

More specifically, in 1945 Malavard (259, 461, 462) studied various characteristics of, essentially, two-dimensional airfoils by planar networks conjoined with analysis, yielding a solution equivalent to the well-known Multhropp approach. Subsequently, the rapid increase of airspeeds with jet aircraft resulted in a shifting to essentially three-dimensional airfoils on such craft. For studying such, Redshaw designed a multi-dimensional resistance-network analyzer comprised of connected planar grids and obtained therewith solutions of numerous problems of practical interest (463–466), such as lift pressure on high-aspect-ratio surfaces at both subsonic and sonic speeds. Bruce (467, 468) has utilized this analyzer to obtain representation of a flexible-walled wind tunnel, minimizing wall effects.

## 27. NUCLEAR REACTOR DESIGN

The complexities of nuclear reactor design are such that finite-difference calculation is much used therefor. Analogously, network determination of the critical conditions, spatial distribution of neutrons in a reactor, and other aspects of interest can be calculated on a unidimensional multigroup approximation of the neutron age equation designed by Spooner (469). A broader resistance-network approach, combined with his procedure of "tearing," is outlined by Kron (470, 471). Recently, Liebmann has utilized all of the resources and techniques gained in his numerous earlier studies of various problems to obtain detailed numerical solutions for two reactors with prescribed rectilinear shapes of core and reflector and prescribed boundary values of flux, as based on the one-group theory. Extension to problems of anisotropic neutron diffusion properties, other spatial distribution, and yet different modifications of the particular problem studied are possible; and still broader extension to nuclear reactor problems described by the two-group theory is feasible (472, 473).

## 28. ALGEBRAIC EQUATIONS

Solution of a set of linear algebraic equations is intimately associated with finite-difference computation. Resistance networks provide a facile means of effecting such solution. Typ-

ical procedures are evidenced in the papers by: Waldmann (474), concerned with nuclear calculations; Walker (475); and by Ramanovrthy and Soroka (476, 477), relative to mechanical vibration investigations.

## 29. MISCELLANEOUS

Newton (478) has studied stress distribution in sheets longitudinally reinforced by stringers and loaded in the plane of the sheet by longitudinal forces; and Pukhov (479) and Melan (480), stress distribution in structural frameworks.

## 30. CONCLUSION

A separate paper on the solution of problems by a-c impedance-network analogs, which require rather different techniques than the continuous and discrete conductive procedures discussed in this paper, is in preparation. For inclusion in an addendum to this second paper, author would appreciate receiving a note giving pertinent references not listed in the present three parts.

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*"Letters to the Editor" and "Books Received for Review" appear after the reviews*

## Theoretical and Experimental Methods

(See also Revs. 381, 383, 395, 423, 473, 475, 542, 564, 576)

**Book—364. Newell, H. E., Jr., Vector analysis,** New York, McGraw-Hill Book Co., Inc., 1955, xi + 216 pp. $5.50.

This is an introduction to vector analysis which assumes no previous knowledge of the discipline, and which develops the algebra and calculus of vectors in a manner suitable for the engineer and physicist. The basic part of the text is given in part I, which consists of eight chapters. Chapter I deals with elementary vector algebra. A survey of some aspects of ordinary calculus is given in chap. 2, leading to a consideration of the vector calculus in chap. 3 which is continued in chap. 4 with a treatment of divergence, curl, Gauss' and Stokes' theorems. Reviewer feels that since divergence and curl are introduced in limiting integral form, their development ought to be made without reference to any coordinate system, but perhaps author is justified in using rectangular Cartesians because this book is intended primarily for the applied scientist. The operator $\nabla$ is introduced in chap. 5 and discussed in chap. 6. A treatment of curvilinear coordinates is given in chap. 7, and chap. 8 is devoted to vector field theory.

Part II, consisting of three chapters, provides illustrative applications of the theory developed in part I. Simple miscellaneous examples of a dynamical nature are considered in chaps. 9 and 10, and a brief sketch of electromagnetic theory appears in chap. 11.

Exposition is quite clear and straightforward, purposely concise in places, with the student completing the text by applying himself to the many exercises, answers to which are supplied. References to further reading are given at the end of each chapter.

G. Power, England

**Book—365. Norden, A. P., Theory of surfaces [Teoriya poverkhnostei],** Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1956, 259 pp. 5 r. 35 k.

This is the most recent textbook for Russian universities and pedagogical institutes. A systematic use of modern vector and tensor methods, developed partly by Russian savants, makes it possible to keep a certain uniformity of presentation and to clear up some more profound internal relations between various groups of questions. In addition to the well-known general advantages of the above methods, author emphasizes also those special properties of vector and tensor calculus which are characteristic for two-dimensional regions.

In its 15 chapters with 99 subtopics volume brings an excellent presentation of all important facts usually covered in a one-year course: Elementary theory of curves and surfaces, theory and applications of both fundamental quadratic forms of a surface, the complex of questions relating to surfaces of revolution, vector and tensor fields on a surface, geodetical lines, theory of sets, mapping, total curvature of a surface as invariant of its internal geometry, surfaces of constant curvature, triorthogonal systems of surfaces, etc. There are 68 instructive figures throughout the text. Paper is good, print excellent, price unusually low. Book concludes with a few references to the Russian literature, a carefully made index, and a brief list of notations.

This is a very valuable work, with many topics also important for fundamental engineering questions (e.g., theory of plates and shells). We warmly recommend it to interested specialists.

V. Vodicka, Czechoslovakia

**366. Lotkin, M., Characteristic values of arbitrary matrices,** *Quart. appl. Math.* **14,** 3, 267–275, Oct. 1956.

Author proposes method for simultaneous approximation of all eigenvalues of an arbitrary square matrix $A$ of complex numbers. Basic ingenious idea is to apply a sequence of similarity transformations to $A$ which will successively reduce sum of squares of absolute values of elements above (below) main diagonal. Explicit unitary transformation matrixes are given. Author asserts that this choice of transformations will assure convergence of the process, i.e., will assure that the decreasing sum of squares of absolute values of supra-(infra-) diagonal elements will actually approach zero, in which case diagonal elements approach eigenvalues of $A$. Reviewer found no justification of such assumption of convergence.

A numerical example for $A$ of third order is presented. A discussion of numbers of operations involved in computer adaptation of method is given.

In reviewer's opinion, basic idea is promising, but there is needed a determination of whether, when, and how convergence of process can be secured, and error can be estimated.

R. F. Rinehart, USA

**367. Li, T., A method for the solution of an eigenvalue problem with a complex matrix,** *J. aero. Sci.* **23,** 7, 705–706 (Readers' Forum), July 1956.

A complex eigenvalue problem is reduced to the solution of a polynomial equation, the coefficients of which can be easily computed according to a simple rule suitable for digital computers.

From author's summary

**368. Rose, M. E., On the integration of non-linear parabolic equations by implicit difference methods,** *Quart. appl. Math.* **14,** 3, 237–248, Oct. 1956.

Author considers a certain class of nonlinear parabolic partial differential equations and gives the solution of them. He obtains this solution by means of the solutions of suitable implicit difference equations on a rectangular lattice and by taking the limit of such solutions as the mesh of the lattice approaches zero.

Problem is solved for a function of the two independent variables, for the mixed initial-boundary value and can be used for investigation of one-dimensional problems; for example, by investigation of the linear flow of heat in the solid bounded by two parallel planes, or of linear flow of heat in a rod moving with velocity $c$ in the direction of its length, etc.

T. Riabokin, USA

**369. Blanc, C., Approximate integration of parabolic-type equations** (in French), *ZAMP* **7,** 2, 146–152, 1956.

The parabolic partial differential equation is replaced by a difference equation using three standard types of replacement. The error in one time step due to each type of replacement is compared by taking the solution as a random function and computing the variance of the error for each type of replacement. Numerical results are presented which show that the variance of the error might not decrease as $b \to 0$.

The effect of considering several steps will be treated in a later paper. The first minus sign in equation (3.1) should be a plus sign.

H. D. Block, USA

**370. Chambers, L. G., A variational principle for the conduction of heat,** *Quart. J. Mech. appl. Math.* **9,** part 2, 234–235, June 1956.

A function $F$ of temperature $\theta$ and its time-derivative $X \equiv \partial\theta/\partial t$ is defined and shown to be a minimum for variations in $X$, $\theta$ remaining constant. No physical interpretation of $F$ is suggested.

S. Paterson, Scotland

**371. Rheinboldt, W., External boundary values in boundary-layer equations** (in German), *ZAMM* **36,** 3/4, 153–154, Mar./Apr. 1956.

For laminar, steady, incompressible flow in the boundary layer of a two-dimensional body, author proves a proposition concerning specification of the boundary conditions of the equation. The proof is not restricted to a solid wall; the general case of any wall velocity is considered. Author formulates problem by specifying the following boundary conditions: (1) the velocity distribution along the wall, both along and perpendicular to the surface, (2) the distribution of longitudinal velocity, perpendicular to the surface at the leading edge, (3) an asymptotic expression for the longitudinal velocity at large distances from the wall. Paper consists of a concise proof that the third condition is superfluous provided that certain requirements of mathematical consistency are satisfied.

An expanded form of this paper has been published in "50 Jahre Grenzschicht Forschung," Braunschweig, Friedr. Vieweg & Sohn, 1955.

W. D. Baines, Canada

**372. Cartwright, M. L., On the stability of solutions of certain differential equations of the fourth order,** *Quart. J. Mech. appl. Math.* **9,** part 2, 185–194, June 1956.

The Routh-Hurwitz criteria for the stability of solutions of linear differential equations of the fourth order are generalized for certain types of nonlinear differential equations of the fourth order by the use of Lyapunov's function $V$. The method is similar to that of Barbasin and Simanov for third-order equations, but yields somewhat less satisfactory results.

From author's summary

**373. Salzer, H. E., Osculatory extrapolation and a new method for the numerical integration of differential equations,** *J. Franklin Inst.* **262,** 2, 111–119, Aug. 1956.

Author introduces a new osculatory extrapolation formula by applying Hermite's osculatory interpolation formula to extrapolation. The new formula is compared with the ordinary expression for extrapolation and checking

$$f_{n+1} = \sum_{m=1}^{n} (-1)^{m-1} (n/m) f_{n-m+1} + \Delta^n f$$

The new formula has the following applications: (1) More accurate extrapolation than is obtainable with the ordinary extrapolation formula; (2) reduced round-off error and less numerical work in checking tables; (3) the main advantage is in solving differential

equations of the form: $y' = \phi(x,y)$. An $n\frac{1}{2}$-point osculatory formula is given as a refining formula for the latter purpose. Stepwise numerical integration of complex functions may be carried out with the same method. Both extrapolation and refining formulas are given for the latter use also. P. P. Biringer, Canada

**374. Davis, P., and Rabinowitz, P., Abscissas and weights for Gaussian quadratures of high order,** *J. Res. nat. Bur. Stands.* **56,** 1, 35–37, Jan. 1956.

Title items have been previously tabulated to 15 d for orders $n$ up to 16. Here tables are given to 20 d for $n = 2$, 4, 20, and 8 (8) 48. Y. L. Luke, USA

**Book—375. Forbes, G. F., Digital differential analyzers, 2nd ed.,** Pacoima, Calif., George F. Forbes, 10117 Bartee Ave., 1955, v + 54 pp. $2.50.

This book is intended for use by persons associated with and very familiar with digital and Bush-type differential analyzers. After a short description of operating principles and scaling, the rest of the book is devoted to discussions and diagrams for setting up the analyzers to handle exponential, trigonometric, algebraic, and inverse trigonometric functions. Also included is discussion for the operation of adders, multipliers and dividers, and for normalization procedures.

For the reviewer, the definition of terms and symbols were far from adequate. Hence, in his opinion, the book is definitely not for a beginner in the field, unless used under instruction and guidance. L. Findley, USA

**Book—376. Forbes, G. F., Digital differential analyzers, 3rd ed.,** Pacoima, Calif., George F. Forbes, 10117 Bartee Ave., 1956, xii + 182 pp. $7.50.

The first ten chapters of this book are a reprint of the second edition. The remaining sections provide discussions and diagrams for setting up the analyzer to handle various problems. Included are examples of partial differential equations, simultaneous linear equations and polynomials.

As for the second edition, the book would be quite useful to those experienced in the field. However, the reviewer believes a beginner would be unable to follow the book except under instruction and guidance. L. Findley, USA

**377. Reethof, G., Analysis and design of a servomotor operating on high-pressure compressed gas,** ASME Semi ann. Meeting, Cleveland, O., June 1956. Pap. 56-SA-20, 9 pp.

Object of investigation was to develop a pneumatic servo capable of fast response at high temperatures. Device consists of two three-way valves operating two self-acting pistons in push-pull, the downstream orifices being controlled by an electromagnet. Detailed study of steady-flow characteristics of this four-way valve is followed by "systems analysis" of the complete control system, including position- and velocity-feedback. Analog-computer study of linearized equations enabled design to meet given performance specification; results were confirmed on a model. Good agreement is partly due to avoidance of nonviscous friction by use of grease-extruding pistons.

Though based on well-known theory, paper shows advantage of using it *before* developing a new device.

N. Ream, England

## Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 419, 475, 548, 583)

**Book—378. Kabalskii, M. M., Krivoshei, V. D., Savickii, N. I., and Chaikovskii, G. N., Typical problems in theoretical mechanics and their solutions [Tipoviye zadachi po teoreticheskoi mekhanike i metody ich resheniya],** Kiev, Gos. Izdat. Tekh. Lit. USSR, 1956, 511 pp. 11 r. 90 k.

No solid familiarity with theoretical mechanics can be gained without solving completely a large number of problems. On the other hand, a beginner is only seldom able to find, in concrete cases, the most convenient approach to the problem in question and he often does much unnecessary work. The aim of the present volume is to help the students in surmounting such difficulties by showing with typical examples from separate branches of mechanics how one has to proceed in treating actual questions.

Subject is divided traditionally into three main sections: statics, kinematics and dynamics. Statics contains 8 chapters (in all, 37 worked examples) on the plane and 4 chapters (21 problems) on the space systems of forces. Kinematics opens with a brief chapter on elementary motions of a particle (12 typical examples), then come two sections dealing with fundamental cases of motion of a rigid body and with complicated types of motion of material points (in all, 24 problems), whereas the remaining three chapters (26 examples) are devoted to combined motions of rigid bodies. Dynamics is divided into two main parts: four chapters on dynamics of a particle (33 completely solved problems) and nine chapters on dynamics of mechanical systems (61 examples).

Separate chapters are of the following standard structure: first of all comes a brief theoretical account of related facts, then an exact statement of all axioms and basic theorems, methodical hints to solving problems of the group in question, and, finally, typical worked out examples, taken for the most part from current Russian collections. The text is abundantly provided with instructive figures. Mathematical presuppositions do not surpass that modest measure known from usual courses of theoretical mechanics.

Paper and print are adequate to the aim of this book, which is recommended also to every one who will or must recapitulate the subject in question. V. Vodicka, Czechoslovakia

**Book—379. Cetaev, N. G., Stability of motion [Ustoicivosf dvizeniya], 2nd ed.,** Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1955, 207 pp. 7 rubles.

This monograph is the second edition of one which appeared in the early thirties and is well known in the Soviet Union but not outside. According to a statement by the author in the preface, this edition does not differ very much from the first.

The monograph is an excellently written and reworked treatment of all the material in Lyapunov's great classic [*Ann. math. Statist.* no. 17] which deals with his second method, and readers familiar with Lyapunov will find no surprise here. There are a few new theorems due to Cetaev himself, and in particular his noteworthy general instability theorem. The point of view is generally physico-mathematical with emphasis on kinetic and potential energies as well as on the Lagrange equations. There are a number of well worked out examples, especially a highly interesting one on airplane stability. Of the extensive research on the inversion of the stability theorems of Lyapunov, all done since the first edition appeared, there is not a trace.

S. Lefschetz, Mexico

**380. Rosenberg, R. M., A pursuit problem,** *J. Franklin Inst.* **262,** 4, 265–279, Oct. 1956.

A pursuit problem is set up with the following conditions: (1) The attacked moves with constant velocity on a straight line, one of whose position coordinates is unknown. (2) The attacker travels with constant speed. (3) The attacker can see at any instant only a single point in its line of sight, this point being at its "range of sight." The problem is to find a trajectory for the attacker which will insure a collision.

The kinematical equations of motion for the plane problem are easy to write down, but yield an integral equation difficult to handle. At this point, author introduces a clever change of variables which reduces the problem to a solvable differential equation

Similar substitutions are introduced to solve the three-dimensional problem. The results of typical initial conditions are shown by diagrams of pursuit curves for the three-dimensional case.

F. Niedenfuhr, USA

**381. Seifert, G., On stability questions for pendulum-type equations,** *ZAMP* **7,** 3, 238–247, 1956.

**382. Johnson, V. R., Vaughn, G. W., and Lavik, M. T., Apparatus for friction studies at high vacuum,** *Rev. sci. Instrum.* **27,** 8, 611-613, Aug. 1956.

A friction test apparatus has been developed which permits accurate measurements under high vacuum. Sliding motion inside the vacuum chamber is accomplished by magnetic coupling through the chamber wall. The lag angle between the magnets, observed by means of stroboscopic illumination, measures the friction. Calibration of the magnetic coupling is obtained from the period of oscillation of the driven magnet with respect to the driving magnet.

From authors' summary

**383. zur Capellen, W. M., Dead centers of the four-bar linkage in analytical representation** (in German), *Forsch. Geb. Ing.-Wes. (B)* **22,** 2, 42–50, 1956.

Relations between the lengths of links and their various stationary points are rigorously determined. Practical rules are given for ease of calculation as well as some nomograms which help to illustrate general conditions and requirements. After pointing out that the exact location of dead centers of a mechanism being synthesized may require determination of link length to a degree not obtainable by graphical methods, author develops analytical expressions for their location. These are then reduced to nomograms for the various forms of the four-bar linkage.

This graphical treatment is directed to the particular problem under consideration and is not as general as the nomographic methods developed by Svoboda.

C. E. Balleisen, USA

**Book—384. Rothbart, H. A., Cams. Design, dynamics, and accuracy,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xiv + 350 pp. $9.50.

Book gives a broad and up-to-date survey of cam design, covering a wide variety of cams as to shapes and applications. It is such a useful book that every designer dealing with cams should have a copy in easy reach for study and for reference. While written for the designer, it is also valuable to serious students of cam kinematics or dynamics. Author uses analytical, numerical, and graphical methods in solving problems but favors the analytical ones, probably because they can be taught more easily. In practice, however, the majority of cams are designed by draftsmen who prefer graphical methods. They would rather make several trial layouts than attack a complex formula to find out that the 2.16-in. radius of curvature of the example on page 85 is greater than the 5/8-in. radius of the roller follower. Similarly, if pressure angle is so slightly critical that it may vary from 20° to 47½°, why the big mathematics for designing a cam with an exact maximum pressure angle? Except for the mental exercise, one would prefer to find the proper size by trial and error.

However, the value of mental exercise should not be minimized. As a good teacher, author proceeds from the relatively simple to the more complicated until he arrives at the point where he is forced to employ oversimplifications to be able to handle the problem at all. This happened to the dynamics of high-speed cam systems, where, in equation 8.2, he ignored spring surge and damping to simplify the treatment. In an example on page 89, on the other hand, author complicates the case unnecessarily by considering the cam rpm, though with another rpm the result would be the same.

A list of references follows each chapter. Restricted to important English language sources the lists are fairly complete. A few significant ones are missing, like Oliver and Mills "Surging of valve springs," Rep. 1945/R/8, Int. Automobile Engineers, Great Britain, where the important work of A. W. Hussmann in Germany is reported on. While they are frequently used, a list of abbreviations is missing.

An excellent chapter is no. 10 on surface materials, stresses and accuracy, subjects which seldom receive such a thorough treatment. Much of the information on unconventional and special cams was new to reviewer and will be to many readers.

The book is nicely printed and profusely illustrated. It is a mighty handy book to have.

P. H. Schweitzer, USA

**385. Rothbart, H. A., Cam dynamics of high-speed systems,** *Mach. Design* **28,** 5, 100–107, Mar. 1956.

A general discussion of dynamic effects in cam follower systems closes with a brief design guide, reinforced by fourteen bibliographic references. Sources of vibration in cam mechanisms are discussed, including chosen follower motion, cross-over shock in body-closed follower systems, jump in force-closed systems, surface irregularities, external loads and vibrations, and cam unbalance. Various cam motions are compared and importance of finite pulse (usually called "jerk") values is emphasized. Sinusoidal and trapezoidal acceleration curves are recommended with order of accuracy necessary to realize their benefits.

D. K. Wright, Jr., USA

**386. Sanderson, A. E., Minimum cam size as determined by pressure angle,** *Prod. Engng.* **27,** 7, 141–143, July 1956.

Formulas, tables, and nomogram for selecting size of cam to keep pressure angle under a specified value are presented.

From author's summary

**387. Rothbart, H. A., Basic factors in cam design,** *Mach. Design* **28,** 21, 107–113, Oct. 1956.

## Servomechanisms, Governors, Gyroscopics

(See also Rev. 377)

**388. Donegan, J. J., and Huss, C. R., Comparison of several methods for obtaining the time response of linear systems to either a unit impulse or arbitrary input from frequency-response data,** *NACA TN* 3701, 39 pp., July 1956.

Comparisons indicate that all the methods give good accuracy for a second-order system, with some differences in computing time. The methods generally classified as inverse Laplace transform methods were found most effective in determining response to unit impulse from frequency-response data for higher-order systems. Discussion and examples show flight-data-analysis techniques for using simple calculations to predict loads and motions of flexible aircraft, with arbitrary input, from known frequency response. Though authors have successfully demonstrated certain comparative features of these methods, reviewer feels that their effectiveness will often be governed by the user's experience with one or the other of these methods.

G. A. Nothmann, USA

**389. Passera, A. L., and Willoh, R. G., Jr., An optimum switching criterion for a third-order contactor acceleration control system,** *NACA TN* 3743, 46 pp., Aug. 1956.

An optimized, third-order contactor system, which causes the actuating signal along with its first and second time derivatives to become zero simultaneously, is developed analytically and by the analog-computer method. The analog-computer method, though not as accurate, is claimed to offer a relatively simple means of locating switching point loci. The third-order criterion yields a response which has no overshoot and which arrives at a steady-

state value in a minimum of time in response to a step input of the controlled variable. Comparison with a second-order system reveals the third-order to be far superior with respect to the time required to reach steady-state, except in cases of large step inputs. J. P. Vidosic, USA

**390. McDonald, D. C., Schover, D. S., and Simmons, A. B., Components at work. A functional analysis of automatic logging systems,** *Control Engng.* **3,** 2, 67–82, Feb. 1956.

Paper is not of research nature. Problem discussed is functional configuration of automatic logging systems used in industrial processes to provide records of the significant variables such as temperature, pressure, etc. Various functional arrangements are analyzed, including those using analog and digital techniques. Types of transducers, scale factor and linearizing circuits, scanners, analog-digital converters, integrators, and programmers used in such systems are classified and described briefly. Paper provides a well-organized qualitative study of the many possible arrangements of such systems and the reasons why certain methods may be selected for a given application.
R. Kochenburger, USA

**391. Benz, W., Influence of delayed torque transmission upon the stability of automatic control** (in German), *Motortech. Z.* **17,** 1, 1–10, Jan. 1956.

A system for speed regulation of a synchronous generator is described by the equations

$$\dot{\phi}(t) = Ay(t) + B\dot{y}(t) \quad \text{and} \quad \ddot{\phi}(t) + C\dot{\phi}(t) + D\phi(t) = Ey(t - t_0) \; (*)$$

where $\dot{\phi}(t)$ is the speed of the generator, $y(t)$ the output of the regulator, $t_0$ a time delay inherent in the torque transmission, $A$, $B$, $C$, $D$, $E$ positive constants. Stability and transient behavior of (*) is investigated by classical methods (semigraphical solution of the characteristic equation). Numerous special cases of (*) as well as examples are included. Paper abounds in remarks of practical and engineering interest and is recommended to engineers concerned with problems of this type. R. E. Kalman, USA

**392. Blokh, Z. Sh., Evaluation of control quality by the analysis of frequency characteristics** (in Russian), *Avtomatika i Telemekhanika* **16,** 3, 258–268, 1955.

Paper starts with the general connection between the step function response $\varphi(t)$ of a closed loop system with given frequency response $\phi(i\omega) = R(\omega) + iI(\omega)$. Some relations between $\varphi(t)$, $\varphi'(t)$ and $R(\omega)$ and $I(\omega)$ are established. These are hence developed into inequalities giving lower limits for amount of overshoot, undershoot, and upper limit for regulation time $t_{reg}$.

These formulas look useful, though the actual value of a quantity may be considerably off the limit value. In an example given in the paper $t_{reg} < 3.6$ sec, according to limit rule, $t_{reg}$ being 1.5 sec. Similarly for the $M_p = 1.3$ condition, the inequalities established give the overshoot > 15%. For a second-order system, $M_p = 1.3$, reviewer has found the overshoot to be 22, 9%.
H. Christensen, Norway

**393. West, R. K., Automatic temperature control . . . a basic automation technique,** *Automation* **3,** 10, 78–82, Oct. 1956.

Though primarily a broad survey of some of the more pertinent points of automatic temperature control, this article can be considered as a review of instrument controls in general. The means of accomplishing automatic control of temperature are based on principles readily applicable to the control of any process variable which can be measured and expressed in terms of electrical equivalents. From author's summary

**394. Raymond, R. E., New ideas for pressure control on oil hydraulic equipment,** *Appl. Hydraulics* **9,** 10, 82–86, Oct. 1956.

**395. Coales, J. F., Historical and scientific background of automation,** *Engineering* **182,** 4724, 363–370, Sept. 1956.

## Vibrations, Balancing

(See also Revs. 385, 520)

**396. Bishop, R. E. D., The general theory of "hysteretic damping,"** *Aero. Quart.* **7,** 2, 60–70, Feb. 1956.

Paper treats the general problem of small oscillations where "hysteretic damping" (solid damping) is assumed between pair of points. Equations are formulated in terms of generalized coordinates, and a "dissipation function" associated with such damping is defined for the Lagrange equations. Properties of "receptances" are made use of in the solution of problems.
[See also AMR **9,** Rev. 1004.] W. T. Thomson, USA

**397. Bishop, R. E. D., The behaviour of damped linear systems,** *Aero. Quart.* **7,** 3, 156–168, May 1956.

Classical theory of small harmonic oscillations of conservative systens is supplemented for the case of "hysteretic damping" (solid damping). Albegraic solution for hysteretic damping is shown to be simpler than those for viscous damping. Effect of small damping on frequency and mode amplitude is discussed.
W. T. Thomson, USA

**398. Anliker, M., Bending vibrations of twisted beams cantilevered at one end and supported at the other end** (in German), *ZAMP* **7,** 3, 248–253, 1956.

Paper presents very interesting numerical results for first four natural frequencies in bending, referring to rectangular cross sections with edge ratios of 1:2, 1:5, and 1:16, as a function of end-to-end angle of twist. J. H. Greidanus, Holland

**399. Bycroft, G. N., Forced vibrations of a rigid circular plate on a semi-infinite elastic space and on an elastic stratum,** *Phil. Trans. roy. Soc. Lond.* (*A*) **248,** 948, 327–368, Jan. 1956.

Theoretical analysis is given for four degrees of freedom of plate. Upper and lower bounds are determined by use of reciprocal theorem of Rayleigh. Resonance occurs in the case of vertical and horizontal translation of the plate attached to the surface of elastic stratum but does not exist for rotations of the plate on the stratum. The effect of damping is discussed. A brief note is given on the technique used in experimental work which gave close agreement with theoretical results. Experimental results are to be published in separate report. P. G. Jones, USA

**400. Bishop, R. E. D., The vibration of frames,** Instn. mech. Engrs. Prepr., 15 pp., 1956.

Paper describes method for finding natural frequencies of a rigid jointed frame formed from straight uniform members. Two or more members of different cross sections, joined end to end to form a stepped member, may also be dealt with.

Receptance functions for individual members are used to form equations of equilibrium which give natural frequencies. Equations may be used to find as many of the frequencies as are required; example giving first six frequencies of a portal frame is shown in which agreement with experiment was within 1% in all cases.
D. C. Johnson, England

**401. Toriumi, I., Vibration in foundation of a machine resting on the ground** (in Japanese), *Zisin* **7,** 4, 216–225, 1955.

Author presents theory on vibration of cylindrical foundation placed on the ground and excited by periodic forces of vertical, horizontal, or rocking component. Analysis is made regarding ground as semi-infinite homogeneous elastic solid in three-

dimensional system, in which effect of initial strain due to mass of foundation is neglected. Infinite integrals are solved graphically on complex plane. It is shown by some numerical examples that resonance occurs in the system at a certain frequency of exciting force, which depends on mass and dimension of foundation and other constants. Amplitude of vibration, however, does not increase to infinite in this case even when no damping factor is considered in the ground.

From author's summary by K. Kasahara, Japan

**402. Kumai, T., Shearing vibrations of ships,** *European Shipbldg.* **5**, 2, 32-37, 1956.

Author proposes that ship hull vibration modes above the fundamental are primarily of the shearing type. Solutions for pure shearing vibration of hulls whose shear rigidity and mass distributions are describable in power series of the length coordinate are given in terms of Bessel functions.

Using an energy method, corrections to the pure shear solutions are made which account for bending moment and rotational inertia. Comparison with some experimental data indicates fairly good correlation. Finally, an empirical formula is presented for use in early design stage calculations. W. Targoff, USA

## Elasticity Theory

(See also Revs. 406, 411, 412, 414, 415, 423, 442)

**403. Doyle, T. C., and Ericksen, J. L., Nonlinear elasticity,** pp. 53-115, Advances in Applied Mechanics, Vol. IV (Dryden, H. L., von Karman, T., and Kuerti, G., editors), New York, Academic Press, Inc., 1956.

Nonlinear elasticity has undergone a striking change during the last decade, mainly due to work initiated by R. S. Rivlin. The present article "attempts to familiarize the reader with the concepts and the mathematical tools which are prerequisites for understanding current literature in this field, to correlate and assess the significance of recent investigations, and to point out areas in need of further investigation." The mathematical tools regarded by the authors as prerequisites consist mainly of general coordinate systems in Euclidean space, base vectors, and tensor analysis of two point fields. The need for these particular notations is bound to be a matter of opinion. Three chapters are devoted to the definitions of deformation measures and the formulation of the general theory in which stress is expressed in terms of a strain-energy function $\Sigma$. This is followed by a discussion of the form of $\Sigma$ when the material of the undeformed body is isotropic, transversely isotropic, and orthotropic. A number of general solutions of special problems are mentioned in which the stress system in a body in equilibrium can be expressed in terms of a general $\Sigma$ for all materials with specified structural properties, e.g., all isotropic materials or all incompressible transversely isotropic materials. Only some of the more recent general solutions are discussed in detail. Chapters IX and X contain a review of various methods used for obtaining solutions by successive approximations. The article closes with very brief accounts of the motion of surfaces in continua, and of generalizations of the theory. A. E. Green, England

**404. Muki, R., Three-dimensional problem of elasticity for a semi-infinite solid with a tangential load on its surface** (in Japanese), *Trans. Japan Soc. mech. Engrs.* (1) **22**, 119, 468-474, July 1956.

A general solution is obtained for stress distributions in a semi-infinite elastic solid under the action of local tangential tractions on the surface. Sneddon's solution with the aid of Hankel transform is very useful for axisymmetric elastic problems, but has not yet been applied to unsymmetric problems. The author extends Sneddon's solution to unsymmetric problems and derives a general expression by means of Hankel transforms. This general solution is then applied to some particular problems such as a tangential load on the surface. Numerical calculations are carried out.

T. Udoguchi, Japan

**405. Sokolowski, M., Orthotropic disks under the influence of body forces** (in German), *Bull. Acad. Polonaise Sci.* **3**, 4, 183-188, 1955.

Author derives the differential equations governing the state of stress for orthotropic media. In the presence of body forces, the equations contain two functions and their derivatives, besides the Airy stress function. The case of cylindrical orthotropy is also considered, and solutions to these plane problems are discussed in detail. When body forces are derivable from a single potential function, solutions are simplified as expected. The examples treated are variants of ones given by S. G. Lechnetsky ["Theory of elasticity of anisotropic solids," 1950]

In reviewer's opinion, no new results have been obtained.

J. J. Brandstatter, USA

## Experimental Stress Analysis

(See also Revs. 442, 606)

**406. Zandman, F., and Wood, M. R., Photostress,** *Prod. Engng.* **27**, 9, 167-178, Sept. 1956.

Paper describes a photoelastic technique in which the structure to be analyzed is coated before loading with a birefringent plastic layer. Strains in the structure are transmitted to the plastic which is then examined with a reflection polariscope. Details of the plastics (liquid and sheet forms), reflection polariscopes, and three applications of the technique are given.

W. Shelson, Canada

**407. Christodoulides, S. P., A photoelastic investigation of prestressed concrete anchorages,** *Civ. Engng., Lond.* **51**, 603, 994-997, Sept. 1956.

**408. Zender, G. W., Experimental analysis of aircraft structures by means of plastic models,** *Proc. Soc. exp. Stress Anal.* **14**, 1, 123-130, 1956.

**409. Foppl, L., Elastic stress distributions in two-dimensionally sliced bodies** (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **22**, 2, 63-70, 1956.

Author summarizes a thesis done under his direction by H. Bufler in the photoelastic laboratory of the Institute of Technology in Munich. The subject is the experimental analysis of the variability of the stresses in two-dimensional elasticity, caused by a rectilinear cut, in the following two cases: (1) The cut is parallel to the edge of a semi-infinite plate under a concentrated normal load; (2) centric or eccentric cut of a circular disk subjected to concentrated diametrical compression.

The result of the analysis shows that every cut causes a discontinuity of the normal stress parallel to the direction of the cut. Also it was possible to recognize that, in consequence of friction forces acting between the two parts in contact, the stress pattern is in general not completely definite. These results allowed us to draw some conclusions about the stress pattern existing in stratified mountains. H. Favre, Switzerland

**410. Rohrbach, C., Automatic measurement and registration of quasistatic strains by means of a string-tension-gage and numerous electronic methods of measuring frequency and time** (in German), *ZVDI* **98**, 26, 1541-1548, Sept. 1956.

A strain gage is described which consists principally of a U-shaped structure which is pressed with its open end against the object whose strain is to be measured. One arm of the U is pivoted at its base so as to permit the open end of the U to accommodate the motion involved in the strain. A wire is stretched across the open end of the U and an electromagnetic transducer, or pickup, is mounted on the inside of the base of the U so as to be sensitive to motions of the wire. The pickup can also be used to excite the wire into its natural frequency of vibration. Changes of strain will cause changes of wire tension and of its natural frequency. This is sensed by the pickup. This frequency is compared with an adjustable standard frequency and the strain is then calculated from the frequency change caused by the strain. The major portion of the paper is devoted to methods of measuring the frequency changes. I. Vigness, USA

**411. Kujundzic, B., Methods of expermiental determination of modulus of elasticity of rocks** (in Serbian), *Naše Gradevinarstvo, Beograd* **10**, 3, 349-358, Mar. 1956.

Elastic properties of rocks are of special importance in design and construction of dams, pressure pipes, and tunnels. The following methods used in Yugoslavia are described: geotechnical (hydraulic press, tin cushion, radial press and testing chamber); geophysical (geoseismical); laboratory. The latter two methods, developed and used by Hydrotechnical Institute in Belgrad, are thoroughly described and illustrated. Tin cushion method consists in measuring deformations exerted by circluar tin cushions of 5 to 6½-ft diam, and then the value of normal deformation is determined from the change of the cushion volume. By the radial press, the pressures are exerted on the periphery of the excavation, 6½-ft diam by 16 tin cushions placed between rock and cylindrical frame. All deformations are recorded by special apparatus.

Reference is made to publications by Lazarević and Kujunžić, H. Breth, M. Kvković, L. André, and L. Jovanović.

J. J. Polivka, USA

**412. Brewer, G. A., Dilation measurements of steel sphere and rock deformations at Kemano, B. C.,** *Proc. Soc. exp. Stress Anal.* **13,** 2, 63-78, 1956.

Tests with pressurized 10-ft steel sphere embedded in rock were carried out to determine value of rock modulus to be used in design of hydraulic penstocks buried in solid rock. Detailed description is given of testing apparatus and technique. Test results show considerable effect of rock support, which is time-dependent owing to creep of rock. F. J. Plantema, Holland

## Rods, Beams, Cables, Machine Elements

(See also Revs. 385, 398, 428, 440, 441, 590, 607)

**413: Prentis, J. M., Analysis of inelastic bending stress in concrete beams,** *J. Amer. Concr. Inst.* **28,** 3, 309-317, Sept. 1956.

The distribution of stresses in the compression zone of a reinforced-concrete beam is nonlinear, but the exact shape of the stress block at failure is open to discussion because of the difficulty in measuring stresses in the concrete. Author proposes a solution of this problem involving a combination of experiment and analysis. Measured strains, moment and conditions of statical equilibrium are involved.

The analysis is based on two assumptions: (1) that the strain distribution is linear at all loads, and (2) that the concrete stress depends on the strain only. Equations are derived which permit computation of the concrete stress in the most stressed fiber from the known strains, locations of the neutral axis, and the corresponding external moments. It is necessary to know the steel stress only at one load level.

The method is illustrated with one example of a prestressed concrete beam. Stress-strain relationship computed from the author's equations is similar to that arrived at by Hognestad from the tests of eccentrically loaded columns.

Paper is an extension of a previous work by the same author. It adds another item to the growing list of methods for determination of the shape of the concrete stress block. It should be of interest to research men concerned with the ultimate strength of reinforced- and prestressed-concrete beams.

I. M. Viest, USA

**414. Pettersson, O., Method of successive approximations for design of continuous I beams submitted to torsion,** *Publ. int. Assn. Bridge struct. Engng.* **15**, 167-186, 1955.

A method of successive approximations is advanced for the calculation of the bending moments acting on the flanges produced at those supports of a continuous I beam in torsion which are not hinged in a vertical direction. In principle, this method can be characterized as a generalized variant of the Cross method. When Saint-Venant's torsional rigidity of an I beam is equal to zero, and when the torsional load therefore produces pure bending of the flanges, the method evolved by author becomes identical with the method of fixed end moments devised by Cross.

In order to adapt this method of successive approximations to practical calculations, author deduces the relations required for the determination of some basic quantities, viz., the carryover factor, the stiffness factor, and the distribution factor for the bending moments acting on the flanges as well as the basic bending moments acting on the flanges in some common cases of torsional loading. Furthermore, these basic quantities are graphically represented in diagrams. The application of the method of successive approximations is illustrated by a numerical example.

From author's summary by A. G. Sharp, USA

**415. Pearson, C. E., Remarks on the center of shear,** *ZAMM* **36,** 3/4, 94-96, Mar./Apr. 1956.

Author reviews two methods for locating center of shear for cantilever beam with end load. These methods are usual ones, one based on flexure analysis and the other on strain energy. Purpose of paper is to examine discrepancy between results of methods and fix limits of difference. Reviewer believes paper will interest students of elasticity and advanced strength of materials.

D. E. Hardenbergh, USA

**416. Haviar, G., Continuous slabs over beams (in** Hungarian), *Mélyépítéstudományi Szemle* **6,** 6, 247-258, June 1956.

**417. Wilkes, E. W., On the stability of a circular tube under end thrust,** *Quart. J. Mech. appl. Math.* **8,** part I, 88-100, Mar. 1955.

**418. Mack, C., The tension in strings wrapped slantwise round cylinders when friction is proportional to a power of the normal reaction,** *Brit. J. appl. Phys.* **7,** 8, 294-296, Aug. 1956.

Paper derives expressions for string tension and normal reaction for title string, assuming that limiting friction acts (1) in direction of string, and (2) parallel to axis of cylinder.

L. Maunder, USA

**419. Martin, L. D., Unique graphical study demonstrates fundamentals of face-gear geometry,** *Mach. Design* **28**, 20, 106-112, Oct. 1956.

## Plates, Disks, Shells, Membranes

(See also Revs. 399, 401, 405, 416, 417, 428, 432, 434, 577, 605)

**420. Freiberger, W., and Tekinalp, B., Minimum weight design of circular plates,** *J. Mech. Phys. Solids,* **4,** 4, 294-299, Aug. 1956.

The theory of minimum weight design of circular thin plates and circular sandwich plates obeying von Mises' yield condition is dis-

cussed. It is shown that the minimum weight design admits a failure mechanism for which the mechanical energy dissipated per unit volume has a constant value throughout the plates. The distribution of the bending moments and thickness throughout the plates are determined.

From authors' summary by T. H. Lin, USA

**421. Symonds, M. F., Minimum weight design of a simply supported transversely stiffened plate loaded in shear,** *J. aero. Sci.* 23, 7, 685–693, July 1956.

Author has given a method for the minimum weight design of a simply supported transversely stiffened plate loaded in shear. The minimum weight design is obtained by using closely spaced stiffeners. The inelastic buckling theory for shear developed by Stowell is used and, to obtain the approximate shear yield stress from the tensile yield stress, Mises yield condition is assumed.

A. M. Sen Gupta, India

**422. Sengupta, A. M., Stress distributions in a thin plate around a hole in the form of a loop of Lemniscate of Bernoulli,** *Bull. Calcutta math. Soc.* **47,** 3, 153–156, Sept. 1955.

**Book—423. Cohen, J. W., On stress calculations in helicoidal shells and propeller blades,** Delft, Uitgeverij Waltman, 1955, xi + 100 pp. (paperbound).

An approximation of a model propellor blade consists of a shell of right helicoidal sector middle surface, with thickness and loading functions only of distance to helicoid axis, and appropriate boundary conditions.

Elastic conditions at middle surface are first derived under various approximations, including quasi-statical ones. It is assumed that distribution of bending moments in a cantilever helicoidal sector can be inferred from corresponding values of a sectorial cantilever plate clamped at inner edge. Solutions of the biharmonic equation are constructed for this case which approximately satisfy the boundary conditions.

These results are used to derive upper and lower bounds for distribution of radial moments in axis of symmetry of a cantilever helicoidal sector. Upper bound is calculated by quasi-statical method, lower bound by distribution of bending moments in a helicoidal strip; these bounds differ little, hence it is believed reasonably accurate strength calculations for helicoidal sectors can be performed.

Very interesting part of paper is comparison of present investigation with methods of Taylor and Rõsingh. Taylor's method is found to be useful for practical strength calculations and is equivalent to quasi-statical method. Rõsingh's method gives somewhat too small stresses for wide helicoidal sectors.

Paper gives a very complete and useful discussion of the difficult stress problems of ship propellors, and is believed to be an important contribution to this field.

B. W. Augenstein, USA

**424. Johnson, M. W., and Reissner, E., On inextensional deformations of shallow elastic shells,** *J. Math. Phys.* **34,** 4, 335–346, Jan. 1956.

Paper is concerned with the analysis of the deformation in thin elastic shells in which the strain in the middle surface of the shell is neglected. The form of the boundary condition along a free edge of such shells and the determination of free inextensional vibration of several geometric configurations are the main concerns of the paper.

In the analysis a general equation is derived for deformation of a shell with free edges. The theory for a shell with a free rectangular boundary under transverse loading is developed. Basic formulas are converted into polar coordinates and their application to a free circular boundary is made. A sample analysis is made of a shallow spherical shell with free edges. The results are compared with Kirchoff's results for a circular flat plate with an approximate correlation for zero nodal circles. An equation for the frequency of free vibration of shallow paraboloidal shells of revolution is evolved in conjunction with limiting parameters for the condition of shallowness.

Paper appears to reviewer to be a definite contribution to technical knowledge in a complex field and has a practical application to current problems in vibration.

E. G. Allen, USA

**425. Wilkinson, J., A note on the Oseen approximation for a paraboloid in a uniform stream parallel to its axis,** *Quart. J. Mech. appl. Math.* **8,** 4, 415–421, Dec. 1955.

**426. Rudiger, D., Stresses and deformations of curved surfaces having a parallelogram as their horizontal projection** (in German), *Öst. Ing.-Arch.* **9,** 4, 265–273, Nov. 1955.

**427. Vorovich, I. I., On certain direct methods in the nonlinear theory of shallow shells,** *Dokladf Akad. Nauk SSSR (N.S.)***105,** 1, 42–45, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville 60, Mass.)

## Joints and Joining Methods

(See Rev. 433)

## Structures

(See also Revs. 400, 407, 413, 416, 417, 428, 432, 434, 577, 605)

**Book—428. Gibson, J. E., and Cooper, D. W., The design of cylindrical shell roofs,** Princeton, N. J., D. Van Nostrand Co., Inc., 1954, xii + 186 pp. $8.50.

Book treats both theoretical and practical considerations for the design of cylindrical shell roofs of reinforced concrete. Design analysis is prefaced by a general statement of the elementary theory for both bending and membrane deformation in shells. Application is then made to cylindrical configurations having constant radius of curvature, the lengths being regarded as short, intermediate, and long. Supports are assumed by transverse girders at the ends with various conditions of support along the straight edges, commencing with free, and including edge beams and prestressed edge beams. In the early sections of the book only uniform gravitational loading is considered, but in subsequent sections there are also treated radial loads, both symmetrical and asymmetrical about the longitudinal centerline.

With these considerations, calculation methods are explicitly given for the calculation of force and moment distribution of both single- and multiple-bay roofs. Procedures are also suggested for design of longitudinal transverse and diagonal shear reinforcement for the shell, edge beams, and transverse girders.

Book has been written for design engineers and may be readily used without prior knowledge of higher mathematics. It is not intended as a text on shell theory and contains virtually no references.

E. Wenk, USA

**429. Cazimir, C., Rigid roof frames spanning 97 feet and reinforced with prefabricated skeleton trusses of concrete bars** (in Rumanian), *Indust. constr. Mater. constr.* **7,** 5, 259–265, May 1956.

Destroyed timber roof of an industrial building in Bucharest was replaced by a concrete frame structure, 360 ft long, without interruption of manufacturing process in the existing plant. This was possible by prefabricating round bar trusses with columns arranged outside the existing walls, 30 ft on centers, interconnected with six continuous purlins of the same type. Concrete was poured in forms attached to these welded skeletons, and a continuous sky-

light box, 22 ft wide and 3½ ft high, consisting of precast members was installed along the ridge. Cross section of frames, 16 × 32 in., reinforced with 4- 1-in. diam top and bottom, and double diagonals 0.8-in. diam; tapered purlins 8–11 × 28 in., reinforced with 4–0.55 in. diam at top, 2–1 in., 2–1.2 in. diam at bottom, and double diagonal-1 in. diam. Embedded tie, 12–1.2 in. diam is suspended at third points by hangers, 6 × 6 in., reinforced with 4 bars, 0.47-in. diam. Author was assisted in structural analysis by E. Tifaru.

J. J. Polivka, USA

**430. Froimescu, A., Influence lines of bending moments in fully restrained arches** (in Rumanian), *Indust. constr. Mater. constr.* **7**, 5, 289–294, May 1956.

Author explains his opinion that the classical method of determining the statically indeterminate values of $M_0$, $V_0$, and $H_0$ acting at the elastic centroid of the arch (as introduced by Mörsch, Strassner and Zavriev) is rather complicated, and discusses the preferable method of virtual displacements, which is also generally known. The application of this method to influence lines is presented on a numerical example (arch spanning 51 ft, with 15.5-ft rise).

J. J. Polivka, USA

**431. Drutu, T., New method of determining elastic deformations of fully restrained arches** (in Rumanian), *Indust. constr. Mater. constr.* **7**, 5, 296–298, May 1956.

General formula to be used for any type of elastic deformation is presented and discussed on the basis of a numerical example in a very simple way, similar to the method of determining elastic deformation of a cantilever. The same procedure is applied to the method of virtual work.

J. J. Polivka, USA

**432. Halmagiu, M., Economy in design and construction of long-span roof trusses assembled of precast prestressed panels** (in Rumanian), *Indust. constr. Mater. constr.* **7**, 1, 50–57, Jan. 1956.

New method of assembling triangular trusses of standardized rectangular precast concrete frames with tensile steel diagonals is described and its advantages, especially economy, thoroughly discussed on the basis of an executed structure spanning 82 ft. Individual panels 6 ft 9 in. long and 10 ft high are tied together by stressed cables, inserted in the center holes of chords, consisting of ten 0.2-in. wires in the upper chord, and 48 0.2-in. wires in the lower chord. Russian (Korovchin) prestressing method was used. Tests with two assembled trusses were carried out; stresses and deflections were measured under increasing loading. The costs are compared with those of similar standard trusses on the basis of amounts of materials required per sq ft of the roof coverage (trusses only). Results of this comparison are shown in the following table:

| Material (per sq ft of coverage): | Standard precast truss: | Prestressed truss: |
|---|---|---|
| Concrete (average thickness), inches | 5.8 | 3.4 |
| Ordinary reinforcement (incl. rolled shapes), pounds | 9.8 | 2.2 |
| Prestressed wires (cables), pounds | .... | 0.3 |

Of interest are amounts of materials of similar trusses designed by author, spanning 165 ft, and arranged 32 ft apart, again calculated per sq ft of roof coverage: concrete, 2.4 in.; steel, 4.2 lb; prestressed cables, 0.9 lb.

J. J. Polivka, USA

**433. Tsai, F.-Y., On the method of propagating joint rotations for analyzing rigid frames of non-prismatic bars,** *Scienta Sinica,* **4,** 4, 609–629, 1955.

Paper presents a method of distribution and propagation of joint rotations similar to Kloucek's, but more general. Derived formulas are applicable only to joints without translation. Determination of fixed points for rotations is not new [see Pasternak, "Berechnung vielfach statisch unbestimmter biegefester Stab und Flächentragweite," Zürich, 1927; and Lie, "Ermittlung der Einflusslinien auf geometrischen Wegen," *Stahlbau* 1943].

E. Rathgeb, Argentina

**434. Ionescu, C., Actual problems in manufacturing slab elements (especially in concrete)** (in Rumanian), *Indust. constr. Mater. constr.* **6**, 1, 28–43, Jan. 1955.

Precast slab elements are described and thoroughly discussed including their various properties and requirements, such as strength, thermal and acoustical insulation and waterproofing, mass production in modular sizes, considering economy in transportation and erection, assembly and connections. Advantages of various types of concrete are summarized, such as high-strength concrete, lightweight-concrete, cellular and prestressed concrete, especially on the basis of tests and studies by the Russian Academy of Architecture (A. V. Vojenski, Matarov). Special study is devoted to the sizes and arrangement of prefabricated slab elements, emphasizing the advantages of two-way arrangement, and assembly of slab elements in such a way that the advantages of continuity can be attained in certain degree. Stress analysis under elastic and plastic conditions is presented with reference to research of Prof. Scramtaev. Bending moments under various supports along the periphery are theoretically derived and graphically presented, both under uniform and concentrated loads. Special chapter is devoted to precast slab elements spanning between portals and frames, with reference to investigations made by Dan Niculescu.

J. J. Polivka, USA

**435. Scordelis, A. C., Pister, K. S., and Lin, T. Y., Strength of a concrete slab prestressed in two directions,** *J. Amer. Concr. Inst.* **28**, 3, 241–256, Sept. 1956.

Authors describe test of 14-ft square slab supported at corners and loaded uniformly. Slab is prestressed in both directions with unbonded cables at mid-depth. Strains and deflections before cracking are compared with results of Marcus difference-equation solution. Cracking stress from elastic theory is compared with sum of prestress and modulus of rupture from beam tests. Ultimate strength results are compared with results from "crack-line" theory (Johansen).

C. P. Siess, USA

**436. Casado, C. F., Application of prefabrication to arch bridges** (in French), *Publ. int. Assn. Bridge struct. Engng.* **15**, 83–93, 1955.

**437. Wyly, L. T., Lagaard, M. B., Kluge, R. W., Lenzen, K. H., Larson, E. W., Jr., and McCammon, E. W., Jr., Dead-load-stress measurement in a long span bridge,** *Trans. Amer. Soc. civ. Engrs.* **120**, 311–339, 1955.

**438. Klingert, N. V., Design of a steel penstock** (in Russian), *Gidrotekh. Stroit,* **22**, 10, 37–39, 1953.

## Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 455, 456, 457, 458, 475)

**439. Hu, L. W., Studies on plastic flow of anisotropic metals,** *J. appl. Mech.* **23,** 3, 444–450, Sept. 1956.

Following Hill's theory of plasticity for anisotropic metals, plastic stress-strain relations for materials with strain hardening are developed. To illustrate the influence of anisotropy on the plastic behavior of metals, the problem of a thick-walled cylinder in a state of plane strain under internal pressure and those of thin-walled tubes in a state of plane stress under biaxial tension-tension or under biaxial tension-torsion are discussed. For the

thick-walled cylinder, it is found that the yield pressure can be increased by reducing the axial strength. For thin-walled tubes, it is observed that the existing methods of interpreting the conventional biaxial-stress test results are valid for biaxial tension-tension tests but are not valid for biaxial tension-torsion tests of anisotropic materials. A. M. Sen Gupta, India

**440. Green, A. P., The plastic yielding of shallow notched bars due to bending,** *J. Mech. Phys. Solids* **4,** 4, 259–268, Aug. 1956.

Deeply notched bars are defined in the sense that initial yielding does not extend to the surface of bars on either side of the notch. Then, shape of slip-line field depends only on the notch root shape and the loading condition. This problem has been considered previously [AMR **7,** Rev. 103; **9,** Rev. 2932].

Present paper deals with shallow notches defined in the sense that initial yielding extends to the surface of bars on either side of the notch. Slip-line field solutions are given and a detailed discussion presented on the critical minimum depth of notch for which the solution for a deep notch is still valid for (a) pure bending with a 60° V-notch, and (b) the IZOD test. Author points out that this critical depth solution shows a feature not previously exemplified. It contains a region where deformation does not occur but where the stress is uniquely determined from the given boundary conditions (plastic-rigid material is assumed throughout).

Reviewer believes paper to be most interesting and informative. M. C. Steele, USA

**441. Seide, P., Elasto-plastic bending of beams on elastic foundations,** *J. aero. Sci.* **23,** 6, 563–570, June 1956.

Equations are derived for the case of a beam on an elastic foundation in which the "fiber stresses" exceed the yield point and in which the stress-strain diagram may be represented by two straight lines. Two methods of solution are offered: a numerical one and one derived from an approximate linearization. Solutions of specific problems, obtained by both methods, are compared with test results.

The elastic foundation is considered purely elastic throughout; which warrants this word of caution in the application of the method or the results to the case of a cylinder element being studied as a beam on an elastic foundation. E. J. McBride, USA

**442. Kuzmanovic, B., Relations between stresses and deformations in bending of steel members and the range of elastic plasticity** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 5, 672–677, May 1956.

On the basis of strain measurements it is shown that cross sections of steel members deform, when stressed beyond the yield point, in curved planes with increasing plasticity due to residual stresses and to different elastic behavior of steel in compression and tension. All tests show higher yield point in bending than in simple tension. The results of tests made in the Institute of testing materials NR Srbije in Beograd are tabulated and plotted in diagrams. Numerical examples demonstrate the effect of this behavior in practical application. Author was assisted in this research by B. Žeželj and B. Petrović. References: Nadai, Freudenthal, Mayer, Bach-Baumann, Dawance, Kuntze, Prager, Stephan, and Pomp-Krisch. J. J. Polivka, USA

**443. Huzimura, T., and Sutoki, T., Elastic after-effect,** *Sci. Rep. Res. Inst. Tohôku Univ. Japan* (*A*) **8,** 2, 79–86, Apr. 1956.

The elastic after-effect was examined with metal wires at various temperatures, and the results are explained by the theory of recovery based on the dislocation model. The formation of polygon boundary or substructure in the course of after-effect is discussed briefly. From authors' summary

**444. Akulov, N. S., and Galenko, P. P., Theory of the plastic deformation of metals** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **103,** 3, 387–390, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 6 pp.).

Authors develop formulas for small static stress cycles. The formulas are analogous to Rayleigh's laws for small magnetic cycles and are interpreted with a model analogous to Preisach's magnetic model [Becker and Döring, "Ferromagnetism," Springer, Berlin, 1939, p. 218; L. Prandtl, *ZAMM* **8,** p. 85, 1928, stated qualitative relations for more general stress histories by analogy with magnetic relations of E. Madelung]. The formulas represent the ascending and descending branches of a small twist versus torque cycle as parabolas; the model is an aggregate of blocks, each having a rectangular hysteresis loop of width $2M_0$ centered about torque $M_b$, and the aggregate has a statistical distribution of values, uniform for small $M_0$ and $M_b$. Experiments on nickel and iron confirm the predicted dependence of hysteresis loss on amplitude; the magnetostrictive contribution present in ferromagnetic materials is stated to have been eliminated by use of a polarizing field or torque. [Rayleigh and Preisach are mentioned, but there are no references, at least none in the translation.] William Fuller Brown, Jr., USA

**445. Green, A. E., and Rivlin, R. S., Steady flow of non-Newtonian fluids through tubes,** *Quart. appl. Math.* **14,** 3, 299–308, Oct. 1956.

Rivlin [AMR **3,** Rev. 912] has discussed that the steady rectilinear flow of a fluid through a uniform tube of circular cross section can be maintained without the application of body forces, and Ericksen [*Quart. appl. Math.* in press] has shown that the maintenance of steady rectilinear flow through the tube in which cross section is noncircular will require that, in addition to a uniform "pressure gradient" along the tube, an appropriate distribution of body forces be applied to the fluid.

In this paper, a suitable distribution of body forces for the maintenance of steady rectilinear flow through a tube having an elliptical cross section is calculated. The concerned fluid is a nearly Newtonian fluid which departs from the ideal Newtonian law in a particular way.

It is found that, for such a fluid, a uniform pressure gradient will produce in the elliptical tube a rectilinear flow on which is superposed four similar vortex-like flows in planes normal to the length of the tube—one in each quadrant of the elliptical cross section—and these have the same signs in diagonally opposite quadrants and opposite signs in adjacent quadrants. H. Mii, Japan

**446. Mariens, P., and van Paemel, O., Theory and experimental verification of the oscillating disk method for viscosity measurements in fluids,** *Appl. sci. Res.* (*A*) **5,** 6, 411–424, 1956.

Paper contains refined theory of very slow motion of a disk of finite radius and thickness oscillating in a very large container filled with the fluid to be measured. It is an improvement of the solutions obtained (during the past 20 years) by Macwood [*Physica* **5,** pp. 374, 763, 1938], Andronikashvili [*Zh. eksp. teor. Fiz.* **18,** p. 429, 1948], de Troyer, van Itterbeek and van den Berg [*Physica* **17,** p. 50, 1950; AMR **5,** Rev. 2483], and Hollis-Hallett [*Proc. roy. Soc.* (*A*) **210,** p. 404, 1952]. The mathematical scheme used is that originally adopted by O. E. Meyer [*Wied. Ann.* 1887]. As shown by reviewer and his collaborators [Brown University, A.F. Office of Sci. Res. Reports AF 891/1 to 7], this scheme cannot fully take into account the effect of the sharp edges of the disk on the flow around it, and hence on its motion. This is also confirmed by recent experimental evidence [J. Kestin and J. R. Moszynski, Fifth Inter. Conf. Properties of Steam, London, 1956] which shows that Eq. (23) of the paper is unsuitable as a basis for absolute measurements in gases, giving an error of from −5% to +3%, although it seems to be satisfactory for liquids.

Reviewer cannot restrain himself from pointing out that this seemingly very simple problem has defied all efforts to solve it

sufficiently accurately for precision measurement, in spite of the fact that it has attracted the attention of numerous scientists (including J. C. Maxwell) for over one hundred years. High-precision viscometry would benefit immensely from an exact solution of this problem.

An alternative approach (but not a definitive solution) was given by J. Kestin and L. N. Persen [9th Inter. Congress appl. Mech.] and J. Kestin and H. E. Wang [to be published in *J. appl. Mech.* ASME Pap. 56-A-34]. J. Kestin, USA

**447. Brunstrum, L. C., and Leet, R. H., Capillary viscometry of lubricating grease,** *Lubrication Engng.* **12,** 5, 316–322, Sept./Oct. 1956.

## Failure, Mechanics of Solid State

(See also Revs. 458, 550)

**448. Nowotny, H., Wear: a physical-chemical problem** (in German), *Öst. Ing.-Arch.* **10,** 2/3, 232–239, 1956.

Two characteristic aspects of wear (dry friction and cavitation) are considered from the point of view of more detailed mechanisms. Using Bowden's studies of friction wear, the role of local energy concentrations and their significance for chemical reactions are discussed. The high local energy densities lead to breakup of grains, loosening of the structure, and produce highly activated and reactive areas. Similar phenomena are observed during a cavitation attack, although the mechanism (concentration of energy through bubble collapse) is different.

From author's summary by R. Smoluchowski, USA

**449. Jaoul, B. J., Study of die wear by means of radioactivated surfaces,** *Trans. ASME* **78,** 5, 1135–1139, July 1956.

The method of surface radioactivation is a further development of radioactive-wear studies. It permits the precise determination of the location of wear. The auto-radiographic method used maps the relief of the die which then can be calibrated against Geiger-Muller tube measurements.

This technique is particularly interesting where wear is a function of time, because it can follow such wear with a non-destructive testing method that is considered safe. Weak points and the concentrations of friction forces can also be determined after a very slight amount of wear.

Finally, the application of this method can be adapted to the study of wear on very large members that cannot be activated throughout their mass, and where wear cannot be determined by the classical methods.

From author's summary by F. Garofalo, USA

**450. Watson, C. E., Hanly, F. J., and Burchell, R. W., Abrasive wear of piston rings,** *SAE Trans.* **63,** 717–728, 1955.

Measuring piston-ring wear by use of irradiated piston rings and modern detection equipment, as was done in tests reported in this paper, is accurate, fast and overcomes any need of disassembling engines.

Tests made with a variety of abrasives showed that size and properties of abrasives influence not only the amount of wear but also its duration.

The same technique would work equally well in studying wear of any irradiated internal engine part in any type of piston engine.

From authors' summary

**451. Ross, S. T., Sernka, R. P., and Jominy, W. E., Some relationships between endurance limit and torsional properties of steel,** *Trans. Amer. Soc. Metals* **48,** 119–148, 1956.

Torsion tests were made on six low-alloy steels quenched and tempered to various hardness levels. The torsional yield strength increased linearly with hardness to some critical value above which the data were more scattered and the strength generally decreased. Previous work had shown a similar behavior in the fatigue limit versus hardness relation, the critical value being about six points Rockwell C below that for the torsional yield strength for each steel. Electron microscopy was used in an effort to correlate the metallurgical structure with the mechanical properties. J. A. Bennett, USA

**452. Valluri, S. R., Some observations on the relationship between fatigue and internal friction,** *NACA TN* 3755, 42 pp., Sept. 1956.

An investigation has been conducted to determine the internal friction and fatigue strength of commercially pure 1100 aluminum under repeated stressing in torsion at various temperatures and stress levels in an effort to find if there exists any correlation between internal friction and fatigue characteristics. For this investigation a torsional fatigue-testing machine of the resonant type was designed with facilities for measuring internal friction at low stress levels.

Results indicate the existence of a critical temperature at which the fatigue life of the specimens appears to reach a minimum value. The effect of this temperature on the internal friction at various stress levels was quite substantial. In addition, the phenomenon of the recovery of internal friction during brief periods of rest was discussed. The recovery of internal friction was observed to depend upon the stress level and temperature of testing.

From author's summary

**453. Hardrath, H. F., Leybold, H. A., Landers, C. B., and Hauschild, L. W., Fatigue-crack propagation in aluminum-alloy box beams,** *NACA TN* 3856, 33 pp., Aug. 1956.

Eighteen box beams constructed according to four designs were subjected to fatigue tests to study fatigue-crack propagation and accompanying stress redistribution. Two designs had stiffeners riveted to the cover, one had stiffeners bonded to the cover, and one had an integrally stiffened cover machined from a plate. Two or more specimens of each design were constructed from each of the aluminum alloys 2024-T3 and 7075-T6. The rate of crack propagation in specimens made of 7075-T6 material was more rapid than that in equivalent specimens made of 2024-T3 and tested at the same nominal stress. Specimens with bonded stringers had lower rates of crack growth than did other specimens. The most rapid rate of crack propagation was found in specimens having covers that were integrally stiffened. The results are discussed with the aid of stress-survey data obtained during the tests. From authors' summary

**454. Calvert, N. G., Experiments on the effect of rate of testing on the criterion of failure of certain mild steels when subject to dynamic torsion and static tensile stresses,** *Proc. Instn. mech. Engrs.* **169,** 44, 903–912, 1955.

Tests at low speed (time to yield about 0.02 sec) and at high speed (time to yield about 0.001 sec) indicate that the effect of increasing speed of torsional component is to move the criterion of yield away from that of constant shear-strain energy toward that of constant maximum tensile stress. Maximum observed torsional stresses are between constant maximum shear stress and constant maximum tensile stress, unaffected by the rate of straining. From author's summary by C. Riparbelli, USA

## Mechanical Properties of Specific Materials

(See Revs. 411, 444, 451, 453, 454, 549, 588, 593)

## Plasticity, Forming and Cutting

(See also Rev. 526)

**455. Hill, R., The mechanics of machining: a new approach,** *J. Mech. Phys. Solids* **3,** 1, 47–53, Oct. 1954.

Author emphasizes poor agreement between experiment and attempts to predict the shear angle pertaining in a given cutting operation. He suggests that the difficulty lies in the existence of many steady-state values of shear plane for a given set of initial cutting conditions. This is a very unexpected suggestion and may be readily shown experimentally to be false. When cutting conditions are changed from a given starting state in different directions, the same result for shear angle is obtained when returning to the initial starting state. This suggests that a unique shear plane does correspond to a given set of cutting conditions.

M. C. Shaw, USA

**456. Whitton, P. W., Computation of roll force and torque in cold-rolling by modern theory,** *J. appl. Mech.* **23,** 2, 307–311 (Design and Data Methods), June 1956.

The full theory for the comparison of calculated roll force and torque with experimental values is outlined. This takes into account the strip elastic compression, the derivation of the yield-stress curves in cold-rolling, and the accurate values for friction coefficient between rolls and strip. Hitherto, the contribution of each of these rolling variables has been found separately. This paper presents the combination of current theory on each. The application of this method yields results within ±5%, a much more accurate comparison than hitherto presented.

From author's summary

**457. Reichenbach, G. S., Mayer, J. E., Kalpakcioglu, S., and Shaw, M. C., The role of chip thickness in grinding,** *Trans. ASME* **78,** 4, 847–859, May 1956.

As usual, Professor Shaw and his associates have made another significant contribution to fundamental knowledge of metal cutting. The role of chip thickness or size effect is related to the density of dislocations in the metal being cut. The results are shown to be an extension of the trends commonly observed in so-called thick-chip metal-cutting operations like milling.

L. V. Colwell, USA

**458. Trigger, K. J., and Chao, B. T., The mechanism of crater wear of cemented carbide tools,** *Trans. ASME* **78,** 5, 1119–1126, July 1956.

Wear of cemented-carbide tools on the top surface is examined in the light of the mechanism of frictional wear as proposed originally by Holm and as recently modified by Burwell, Strang, and Archard. It has been found that wear at the top surface is essentially of the transfer type, and that crater wear is strongly temperature dependent. For a given tool-work combination, top face wear can be correlated with tool-chip interface temperature and predicted from simple laws of adhesion wear in combination with theory of rate process.

From authors' summary by J. J. Dziewonski, India

**459. Ling, F. F., and Saibel, E., On the tool-life and temperature relationship in metal cutting,** *Trans. ASME* **78,** 5, 1113–1117, July 1956.

Empirical relationship of Schallbroch, Schaumann, and Wallichs between tool life and cutting temperatures is examined in the light of recent developments in rupture theory. Cutting-tool failure is viewed essentially as a rupture process, and the data relating tool life and cutting temperature are interpreted from a reaction-rate theory point of view. The significance of cutting temperature is examined critically and its limitations are pointed out.

Reviewer considers paper an interesting and important attempt at linking tool life with fundamental properties of matter.

J. J. Dziewonski, India

**460. Maeder, E. G., Differential annealing, a new technique for improving deep drawing,** *Engineering* **181,** 4694, 48–52, Jan. 1956.

## Hydraulics; Cavitation; Transport

(See also Revs. 394, 522)

**Book—461. Gardel, A., Surge tanks: Analysis of the usual hypothesis—Methods of rapid calculations [Chambres d'equilibre: Analyse de quelques hypothèses usuelles—Méthodes de calcul rapide],** Lausanne, F. Rouge & Cie S. A., 1956, × + 158 pp.

Book reviews some usual fundamental hypotheses made in surge tank calculation and gives important additional material.

The first chapter deals with the assumption of a stable upstream reservoir. Equations are developed for the case when — the reservoir area being small—the water level in it oscillates with the level in the tank.

Chapter 2 expands and slightly amends the well-known "Gardel formula for surge tank stability" previously published by A. Stucky in his "Lecture notes" at Lausanne Technical University [See Ch. Jaeger: "Engineering fluid mechanics," pp. 250–251].

Chapter 3 deals with the losses occurring at the junction point of the surge shaft and the pressure tunnel.

These two last chapters bring new material of fundamental importance to surge-tank design. The problem of the velocity head $v^3/2\,g$ as a stabilizing factor in surge-stability problems is dealt with at full length for the first time.

Chapters 4 and 5 are on simplified methods for rapid surge calculations. These two chapters are illustrated by many diagrams which enable easy choice of the tank area and volume.

C. Jaeger, England

**462. Richards, R. T., Water-column separation in pump discharge lines,** *Trans. ASME* **78,** 6, 1297–1306, Aug. 1956.

Author indicates lack of information available on surges due to water-column separation in lines following pump failure or valve closure. He shows results of investigations conducted on existing pipelines including one steam-station, circulating-water system.

Author concludes that water-column separation problem is common and will become more prevalent with extensive use of vertical pumps. Mathematical analysis of pressure surges created involves laborious procedures which may or may not be warranted, but author speaks for continuing field tests in order to have empirical data available for future use. J. S. Marcus, USA

**463. Straub, L. G., Silberman, E., and Nelson, H. C., Some observations on open channel flow at small Reynolds numbers,** *Proc. Amer. Soc. civ. Engrs.* **82,** EM 3 (*J. Engng. Mech. Div.*), Pap. 1031, 28 pp., July 1956.

Paper is confined to a summarization and correlation of the results of a number of theses studies on open channel flow in the range of Reynolds numbers below about $4 \times 10^4$. Hydraulic diameter is used as the length parameter in Reynolds number. Smooth laminar, smooth turbulent, rough laminar, and rough turbulent flow are considered separately, as is transition from laminar to turbulent flow in smooth channels.

Results indicate that, at these small Reynolds numbers, smooth channel flow, both laminar and turbulent, is quantitatively similar to smooth pipe flow. Rough channel flow is probably qualitatively similar to rough pipe and rough plate flow, but there is no adequate method available to correlate rough flows in the small Reynolds number range. Channel shape is important in laminar flow, but its entire effect may be determined theoretically. There is only a negligibly small channel shape effect in smooth, turbulent flow and a somewhat more pronounced effect in rough, turbulent flow. Transition generally occurs at slightly higher Reynolds numbers in channels than in pipes, the exact effect depending on shape.

From authors' summary

**464. Escoffier, F. F., Transition profiles in nonuniform channels,** *Proc. Amer. Soc. civ. Engrs.* **82,** HY 3 (*J. hydr. Div.*), Paper 1006, 19 pp., June 1956.

Author reports some results of previous authors on prismatic channels when critical discharge $Q_c = K(S_c)^{1/2}$ is equal to normal discharge $Q_n = K(S_0)^{1/2}$ ($S_0$ is slope of bottom of channel), and hence studies the same problem in nonuniform channels.

In uniform channel the profile defined by the equation $Q_n = Q_c$ is called transition profile. If, however, $Q = Q_n = Q_c$, the water-surface profile intersects the transition profile and one may have a water-surface profile with $dy/dx > S_0$ or a water-surface profile with $dy/dx < S_0$.

Extension of result to nonuniform channels is made using the concept of paranormal discharge $Q_n' = K(S_k)^{1/2}$ (introduced from Massé). Equation obtained then has a singular point and this may be studied with Poincaré's theory.

Reviewer remarks that Escoffier's results are certainly valid in the neighborhood of the singular point, but it would be necessary to know which form of water-surface profile is possible in a finite length of the channel. For instance, in uniform rectangular channel it may be shown that $dy/dx$ always is $> S_0$ (and never $dy/dx < S_0$). This fact may be verified for every uniform channel in which $Q^2b/gA^3$ ($b$ breadth of the water-surface) can be put in the form $\alpha y^n$. [See, for instance, Puppini, "Idraulica," Bologna, 1947, p. 373.] G. Supino, Italy

**465. Poggi, B., High-velocity flow in open channel curves** (in Italian), *Energia elett.* **33,** 5, 465–480, May 1956.

Author gives an account of three series of experiments in open rectangular channels with different slopes and curves. He compares his results with those of von Karman and Ippen-Knapp. A feature of the experiments was the accuracy of the measurements.

P. Franke, Germany

**466. Dumitrescu, D., Contribution to the study of fluids with free surfaces (in French),** *Acad. Repub. pop. Rom. Rev. Mecan. appl.* **1,** 1, 89–105, 1956.

After giving general and theoretical considerations concerning fluids with free surfaces and a short statement of his two previous works, author deals in detail with particular cases.

The first case concerns the effect of air resistance upon the laminar flow of a liquid with free surface. In the case of a uniform and permanent flow, the integration of the system is reduced to a Dirichlet problem. In both of the particular solutions which are studied, one finds that the speed is maximum at the points situated above the free surface.

In the second case, distribution of speeds in a fluid with free surface, one finds an exact solution of the system of differential equations due to Reynolds for a turbulent movement; this solution is expressed with elliptic functions. It coincides with the experimental data.

The approximate solution given for numerical calculations shows a great similarity to Karman's formula concerning pipes.

From author's summary by L. Escande, France

**467. Kovacs, G., The determination of hydraulic parameters, characteristic of flood waves** (in Hungarian), *Hidrologiai Közlöny* **35,** 11/12, 394–423, Nov./Dec. 1955.

The energy and continuity equations are applied to unsteady flow in a regular channel with uniform depth and infinite width. The discharge curve is assumed as a straight line for the rising branch and a parabola of $\frac{2}{3}$ power for falling branch. The slope was computed for a permanent and uniform flow; subsequently, it was corrected for effect of natural channel, multiplying it by a ratio $m^3/m^n$, where $m$ is a depth and $n$ is a hydraulic exponent in the Bakhmeteff equation of nonuniform flow. Differential equations are to be solved graphically. The explained way can be applied to the forecast of flood waves, determination of channel storage, and operation of reservoirs. S. Kolupaila, USA

**468. Benedict, P. C., Alberton, M. L., and Matejka, D. Q., Total sediment load measured in turbulence flume,** *Trans. Amer. Soc. civ. Engrs.* **120,** 457–489, 1955.

**469. Rastislavov, A., Flood control and coefficient of roughness on the river Tamiš** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 6, 809–813, June 1956.

Knowledge of maximum probable flood flows is important for prevention of serious damage and possible protection. Presented method of determination of maximum flow on the basis of coefficient of roughness is developed and is applied to flood conditions in 1940. J. J. Polivka, USA

**470. Bogardi, J., Typical relations between the transport of rolled alluvia and the hydraulic characteristics of water courses** (in Hungarian), *Hidrológiai Közlöny* **36,** 2, 108–112, Apr. 1956.

An attempt is made to derive empirical relationships expressing the amount of material transported on the river bed as a function of a single hydraulic variable. This variable can be (1) the river level (measured from an apparently arbitrary datum!!), (2) the flow rate of the river, (3) the mean velocity of the river. In reviewer's opinion, the data presented do not justify in any way the assumption of the simple relationships shown in the paper.

G. Sved, S. Australia

**471. Popov, M., Model experiments on the atomization of liquids** (in Rumanian), *Acad. Repub. pop. Rom. Rev. Mecan. appl.* **1,** 1, 71–88, 1956.

Author determines law of similarity for the atomization of liquids having constant properties of state, and verifies it by experiments. The results show that the influence of gas viscosity is very small, and that model experiments can be executed with adequate accuracy without satisfying the constancy of ratio of gas viscosity to liquid viscosity. Equations have been derived for the motion of the gas and of the liquid droplets, and for the limits of their validity. By introducing dimensionless ratios, the equations for drop size could be determined in a simplified form. Comparative tests were made of a hydraulically atomizing system, and a fair agreement was found between the theoretically and the experimentally obtained values of drop sizes and drop-size frequency. The derived laws of similarity facilitate the experimental exploration of the atomizing process and the generalization of the conclusions obtained.

K. J. DeJuhasz, Germany

**472. Euteneuer, G. A., Influence of surface tension on the development of hollow liquid jets** (in German), *Forsch. Geb. Ing.-Wes. (B)* **22,** 4, 109–122, 1956.

Hollow liquid jets can be produced in two ways: (1) by means of nozzles having an annular orifice whereby the walls of the orifice may form a cylinder or a cone, and (2) by means of cylindrical nozzles in which, in the upstream portion, a rotation is imparted to the flowing liquid, which, on its exit from the nozzle, is driven radially outward by the centrifugal force. Author calculates the form of jet under the simplifying assumption of frictionless flow. The contour of the jet, as determined by the dimensions of the nozzle, the efflux velocity, and the density and surface tension of the liquid, agreed substantially with the observed values, up to the point at which the jet disintegrated. At low efflux velocities it can happen that the jet closes up again after a certain travel, owing to the influence of the surface tension, and no atomization takes place. By suitable grouping of the influencing quantities there remain, as parameters for the jet contour, only the Weber number, the radius of the nozzle, and the cone angle of the orifice.

The calculations are executed for water and for fuel oil. The experiments were made with a nozzle having adjustable vanes in the flow passage whereby the rotation imparted to the liquid could be varied. A central tube was provided for admitting air to the inside of the hollow jet. The decrease of kinetic energy along the jet surface owing to the work absorbed by the surface tension is calculated. K. J. De Juhasz, Germany

**473. Hugues, L., Theoretical determination of the shape of an overflow, giving a specified discharge law** (in French), *C. R. Acad. Sci. Paris* **242,** 16, 1956–1959, Apr. 1956.

Water is assumed to overflow through a notch cut in the top of a dam; the profile of the notch is to be determined so that the overflow rate depends in an arbitrarily specified manner on the height of the water surface behind the dam.

The problem is reduced to the solution of an integral equation which is similar to that of Abel and is solved in a similar way.

As examples, profiles giving various power laws of discharge are determined. A. H. Armstrong, England

**474. Galperin, R. S., Scour below spillways** (in Russian), *Gidrotekh. Stroit.* **25,** 3, 51–53, 1956.

Acrylic powder was selected as the most suitable index for laboratory experiments with scour below dams. Its particles are perfectly spherical, 0.15 to 0.30 mm in diameter, moistureproof, therefore with a constant specific gravity, 1.17 to 1.18. These particles already start to shift at 12 cm/sec, their hydraulic size is 0.5 to 0.6 cm/sec; these properties are very convenient for studies.

A relationship was derived for a spillway of standard profile

$$h/H = 0.2\,(100\,t/T)^{0.35}$$

where $h$ is the depth after time $t$, $H$ is a final depth of scour, $T$ is a total time until stabilization of the scouring process. Surprisingly, these results are independent of the relative discharge.

S. Kolupaila, USA

**Book—475. Hamel, G., Mechanics of the continuum [Mechanik Der Kontinua],** Stuttgart, B. G. Teubner Verlagsgesellschaft, 1956, 210 pp. DM 29.70.

"Mechanik der Kontinua" is the last in a series of texts, including "Grundbegriffe der Mechanik" and "Theoretische Mechanik," by Georg Hamel. At the time of his death the work was completed in handwritten form, and most of it had already been typed. The consequent labor of overseeing its publication was undertaken by one of his former students, Prof. Dr.-Ing. István Szabó. Hamel studied at a University, but taught in a Technische Hochschule. With this background it might be expected that his texts would satisfy the demands of university-bred scientists for logical and elegant development and derivation of general principles and at the same time teach engineering students how to apply these principles. This, the reviewer believes, has been accomplished in the present work. Furthermore, the book is remarkable in that, in a space of little over 200 pages, it includes not only much of the classical material but also depicts current research in many fields.

The broad title, "Mechanik der Kontinua," may be somewhat misleading, since about 90%, of the book is devoted to fluids. Yet, even in the one chapter devoted to more general deformable systems, one finds brief discussions and references to recent work, such as in plasticity and rheology.

It is assumed that the mathematical training of the reader includes vector analysis, advanced calculus, and the theory of functions of a complex variable. Unfortunately, most first-year graduate students in engineering in this country do not have this background, so that this book, or its translation, could be used only with supplementary lectures of a mathematical nature.

Because of space limitations and the broad scope of the subject matter treated, it is inevitable that the author would show personal preferences in favoring some topics over others. Thus, whereas free-streamline flows are treated with unusual thoroughness, reviewer considers the treatment of incompressible, three-dimensional, potential flows to be inadequate. Also suffering from brevity are the introduction to conformal mapping, where the invariance of the stream function and its significance are not mentioned, and the proof of Helmholtz's third law of vortex motion, which seems too concise to be intelligible.

On the whole, reviewer has found the book refreshing and stimulating. Hamel was clearly a master of the subject, as is evidenced not only by his clear and occasionally penetrating presentations, but by references to his own researches and the recent work in the field. L. Landweber, USA

**476. Domm, U., The stability of vortex streets with consideration of the spread of vorticity of the individual vortices,** *J. aero. Sci.* **22,** 11, 750–754, Nov. 1955.

This investigation concerns the stability of vortex streets consisting of two parallel rows of staggered real vortexes of identical structure whose vorticity spreads with time into the ambient fluid. It is found that for the case of stability the ratio of centerline width and pitch of the street is a function of the nondimensional time $\tau = (4\nu/l^2)t$, where $\nu$ is kinematic viscosity, $l$ pitch of the vortex street, and $t$ time. For vanishing viscosity and also for vanishing time, the value calculated by von Karman, $k = h/l$ 0.281, is obtained.

From author's summary by I. Michelson, USA

**477. Betz, A., Approximative formulas for the circulation distribution of cascades in narrow blade passages** (in German), *Z. Flugwiss.* **4,** 5/6, 166–169, May/June 1956.

The distribution of circulation along the blades of a centrifugal rotor is computed approximately. It is assumed first that the blades are very thin and closely spaced. The circulation then depends upon kinematic relations only. For finite blade spacing and for blades with thickness, assumptions are made which permit the development of approximate formulas for the bound vorticity. The most serious approximation is the assumption that the vorticity and blade thickness are distributed along a radius instead of the real blade shape. H. W. Emmons, USA

**478. Lieblein, S., and Roudebush, W. H., Theoretical loss relations for low-speed two-dimensional-cascade flow,** *NACA TN* 3662, 46 pp., Mar. 1956.

Relations between wake characteristics and total pressure defect are theoretically analyzed for incompressible flow across a two-dimensional cascade of compressor blades. Results indicate that the total pressure loss coefficient for unseparated flow varies almost directly with the ratio of wake-momentum-thickness to blade-chord-length and with the solidity, and inversely with the cosine of the air outlet angle. Calculations indicate that the additional loss incurred in the mixing of the wake is a function primarily of the form factor of the wake at the start of the mixing, and also that the mixing loss may be a significant proportion of the loss at the trailing edge. The effect of trailing edge thickness is indicated to be possibly significant for conventional compressor blade sections. On the basis of the analysis, wake momentum thickness and form factor are suggested as significant parameters for the presentation and correlation of two-dimensional cascade loss data.

From authors' summary by W. L. Haberman, USA

**479. Constantinescu, V. N., Laminar flow of a gas in a narrow channel** (in Rumanian), *Acad. Repub. pop. Rom. Comun.* **6,** 2, 281–284, 1956.

**480. Pearcey, T., and Hill, G. W., The accelerated motion of droplets and bubbles,** *Austr. J. Phys.* **9,** 1, 19–30, Mar. 1956.

Solutions are first presented for the drag due to impulsive motions of droplets and bubbles, according to the Oseen equations. The droplet is assumed to be a rigid sphere, with zero slip at its boundary, while the bubble boundary condition is continuity of shear stress and velocity at its surface. It is found that the drag expression consists of three terms: (1) a viscous force which would be experienced in the case of uniform translation; (2) a time-variable component which is infinite at $t = 0$ and decreases at $t^{-1/2}$; and (3) a transient force which occurs only at $t = 0$ and is due to

the momentum transferred to the medium by the sudden change in velocity.

The equations for the deceleration from uniform motion of droplets and bubbles are next examined, using the drag function previously determined. Solutions are obtained numerically. It is found that, because of the finite rate of diffusion of vorticity, the distance travelled before a droplet comes to rest is influenced by the past history of its accelerations; the magnitude of the effect depends on the relative densities of the droplet and surrounding medium and the coefficients of viscosity.

It is pointed out that laboratory experiments to simulate motions of drops and bubbles must, for dynamical similarity, be conducted with the prototype value of the parameter $\lambda^2 = 9\rho\xi/\pi\ (2\rho_1 = \rho)$, where $\rho$ and $\rho_1$, and $\eta$ and $\eta_1$, are the densities and viscosities of the surrounding medium and the droplet, respectively, and $\xi = (3\eta_1 + 2\eta)/(3\eta_1 + 3\eta)$. L. Talbot, USA

## Incompressible Flow: Laminar; Viscous

(See Revs. 377, 445, 446, 466, 467, 472, 482, 501, 502, 505, 521, 523, 543, 594, 602)

## Compressible Flow, Gas Dynamics

(See also Revs. 504, 506, 511, 516, 535, 536, 555, 556, 578)

**481. Guderley, G., On transonic airfoil theory,** *J. aero. Sci.* **23,** 10, 961–969, Oct. 1956.

Transonic behavior of three-dimensional flow about wing of large but finite span was analyzed qualitatively through introduction of conjugate potential $\phi\ (u, w, y)$ defined by Legendre's contact transformation, employing a mixed hodograph mapping; i.e., in terms of velocity coordinates in a plane to spanwise direction and physical coordinates along the span. Under transonic hypothesis, the differential equation for conjugate potential becomes linear for terms not containing $y$ derivatives; which is that for plane flow, and can be transformed into Tricomi equation. By introducing the aspect ratio $t^{-1}$, a parameter for the affine family of wing bodies defined by $q\,(x/t, z/t, y)$, it was shown that $\phi\ (u, w, y)$ can be expanded in powers of $t$, and the contribution of terms containing $y$ derivatives amounts to higher-order correction.

A detailed discussion of the solution of Tricomi equation near origin further brings out the fact that, no matter how large the aspect ratio, it is never possible to entirely disregard the nonlinear terms in the flow field; indeed, flow at distance effectively effects that close to the profile. This effect is taken care of by a boundary condition imposed on the latter by the former, formulated through transonic similarity rule.

Results of analysis indicate that deviation of pressure distribution from that of plane flow at Mach number one is proportional to $t^{1/2}$. H. S. Tan, USA

**482. Linnell, R. D., and Bailey, J. Z., Similarity-rule estimation methods for cones and parabolic noses,** *J. aero. Sci.* **23,** 8, 796–797 (Readers' Forum), Aug. 1956.

**483. Vincenti, W. G., Wagoner, C. B., and Fisher, N. H., Jr., Calculations of the flow over an inclined flat plate at free-stream Mach number 1,** *NACA TN* 3723, 70 pp., Aug. 1956.

A numerical solution has been obtained of the complete equations of inviscid compressible flow for the case of an inclined flat plate at free-stream Mach number 1. The mixed flow about the lower surface of the plate is found by relaxation solution of a boundary-value problem in the hodograph plane. Considerable preliminary analysis is required by the presence of the free-stream singularity, which must be incorporated analytically into the numerical work. The methods devised for this part of the work may have application in other problems of transonic flow. The supersonic flow on the upper side of the plate is found in the physical plane by a standard form of the method of characteristics.

The calculations here are carried only as far as the end of the separated region that appears on the upper surface near the leading edge. The results, which are for an angle of attack of 13°, show the pressure distribution on the lower surface and the leading edge. The results for the flow field show that the large changes of velocity that occur near the leading edge are confined to a surprisingly small part of the field. The calculations of the pressure distribution indicate that Guderley's earlier solution on the basis of the transonic small-disturbance theory gives reasonably accurate results even at the present moderately large angle of attack. If the small-disturbance values are corrected by a method also due to Guderley, the error is almost completely eliminated except at the leading edge, where the corrected solution still cannot represent the true flow.

From authors' summary M. H. Bertram, USA

**484. Bomelburg, H., Generalization of Karman's similarity law for transonic flow** (in German), *Z. Flugwiss.* **3,** 9, 313–322, Sept. 1955.

A generalized similarity law for two-dimensional compressible flow around thin airfoils is developed. The law includes Prandtl-Glauert's rule for subsonic flow, Karman's similarity law for transonic flow, and Ackert's theory for supersonic flow. Use of the law is aided by a chart. Result is compared with experiments.

In reviewer's opinion, the proposed law is rather complicated. It does not give better results than the more simple laws proposed by Oswatitsch [AMR **6,** Rev. 2579], Spreiter [AMR **5,** Rev. 3480], and others. T. R. Gullstrand, Sweden

**485. Von Baranoff, A., Lift on a plane surface decelerated through the speed of sound** (in French), *Rech. aéro.* no. 51, 19–25, May/June 1956.

After stating the (linearized) problem defined in the title, it is shown that the preliminary calculation of the downwash generated during the supersonic part of the motion permits the subsonic phase to be treated by the Evvard-Ward method. The method of calculating the downwash is indicated, but the details of this part of the study are not given. Numerical results for the slope of the lift-coefficient, incidence curve as a function of the Mach number, are given for a particular value of the deceleration.

From author's summary by L. C. Woods, Australia

**486. Kawamura, R., and Saito, H., Reflection of shock waves—1, Pseudo-stationary case,** *J. phys. Soc. Japan* **11,** 5, 584–592, May 1956.

A shock wave may reflect at a fixed boundary either regularly or in a Mach reflection where the incident shock, the Mach stem, and the reflected shock meet at a point. Generally speaking, for weak shock waves, there is large disagreement between the theoretically predicted shock-wave angles at the triple point and the results of shock-tube and wind-tunnel experiments. Authors discuss the disagreement between theory and experiment in the vicinity of the transition from regular to Mach reflection.

It is noted that when the Mach number behind the reflected shock is subsonic (weak shock waves), the predicted discontinuity in the angle of the reflected shock wave at transition is not observed. Shock polar diagrams are used in the pressure, flow direction plane instead of the usual hodograph. It is shown that the subsonic region in the diagram, opened up at the start of Mach reflection, is contained in a very small region in the physical plane. As a result, the reflected shock angle would appear to change continuously in a way analogous to what occurs near the angle for shock-wave detachment from a wedge.

Also shock-tube results are presented, similar to those reported by the Princeton group [W. Bleakney and A. H. Taub, *Rev. mod. Phys.* 21, p. 584, 1949]. J. Sternberg, USA

**487. Willmarth, W. W., The optimum distribution of lift in certain prismatic regions at supersonic speed,** *J. aero. Sci.* **23**, 8, 800–801 (Readers' Forum), Aug. 1956.

Consider various arrangements of thin airfoils limited to the interior of a given three-dimensional region $R$, and suppose further that the system is required to develop a certain total lift $L$. The problem is to find a distribution of lateral or lifting pressures which minimizes the drag of the system in linearized frictionless flow (i.e., wave drag plus vortex drag).

According to reviewer's criterion, such a distribution will result in a uniform downwash throughout $R$ when the perturbation velocities in forward and reversed motion are superimposed. In the present note, author shows that this criterion is satisfied for certain prismatic regions by arrangements of single flat airfoils equipped with vertical end plates. R. T. Jones, USA

**488. Meyer, R. E., Perturbations of supersonic nozzle flows,** *Aero. Quart.* **7**, 1, 71–84, Feb. 1956.

Small steady perturbations of general two-dimensional, steady, shock-free, supersonic flows are studied and the perturbation fields of symmetrical nozzle flows are described in detail. The relation between errors in the shape of the supersonic portion of the nozzles and the deviations in the uniformity of the flow in the test section is given to an approximation sufficient for the treatment of a number of problems arising from experiment and in the design of nozzles.

Reviewer believes this paper will assist the designer in cases where refinement of flow properties is needed in supersonic flows. S. J. Kline, USA

**489. Patraulea, N. N., Supersonic flow around a triangular wing which is passing through a circular cone** (in French), *Acad. Repub. pop. Rom. Rev. Mecan. appl.* **1**, 1, 57–61, 1956.

According to the author the problem considered is the steady supersonic flow around a triangular wing which is passing through a circular cone. What exactly this means physically it is difficult to determine. The standard Busemann technique is used and a complete solution seems to be given of some problem, although it is difficult to say what this problem is.

G. Temple, England

**490. Etkin, B., Numerical integration methods for supersonic wings in steady and oscillatory motion,** *Univ. Toronto Inst. Aerophys. Rep.* 36, 37 pp. + 22 figs. + 4 tables, Nov. 1955.

In *SAAB TN* 6, V. Linnaluoto gave a simple numerical method for the approximate calculation of the perturbation potential of linearized supersonic wing theory in the case of nonlifting symmetrical wings. This note gives an extension and generalization of Linnaluoto's method with regard to thin lifting plates for the two cases (a) steady flow, (b) harmonically oscillating flow; only wings with supersonic trailing edges are considered.

To make possible such a procedure it is necessary to know the upwash field upstream of the wing. Wings with supersonic leading edges provide no difficulties in this respect, neither in case (a) nor in case (b). For wings with one subsonic and one supersonic leading edge, Evvard's equivalent-area theorem lends itself to determine exactly the effects of the upwash field: in case (a), always; in case (b), at least for zero order (quasisteady flow) and for first-order oscillations (terms of second and higher order of frequency are neglected). If both leading edges are subsonic, a further approximation is necessary by neglecting more remote and therefore irrelevant parts of the unknown upwash field.

Paper summarizes previous investigations of the author with regard to case (a). [AMR **8**, Rev. 2436.]

Numerical tables are given for the analog of Linnaluoto's distance matrix in both cases (a) and (b). Some examples for wings with analytically known potential give an idea of the accuracy of the method, which appears to be sufficient for engineering purposes. H. Behrbohm, Sweden

**491. Martin, J. C., and Malvestuto, F. S., Jr., Aerodynamics of a rectangular wing of infinite aspect ratio at high angles of attack and supersonic speeds,** *NACA TN* 3421, 114 pp., July 1955.

Graphs are presented for some section aerodynamic stability derivatives for an infinite span flat plate at supersonic speeds when either at an angle of attack, pitching, plunging, or rolling. The upper-surface flow expansion pressures were determined by linearized potential equations. The lower-surface pressures were calculated by including first-order effect of the rotational flow produced by the inclined attached supersonic shock wave.

It was found for Mach numbers greater than 2 with angles of attack above $10^\circ$ that the change in entropy in the perturbed flow behind the shock wave must be considered since it has as much effect as the change in entropy in the boundary conditions on the velocity perturbations on the shock wave.

E. V. Laitone, USA

**492. Brajnikoff, G. B., and Rogers, A. W., Characteristics of four nose inlets as measured at Mach numbers between 1.4 and 2.0,** *NACA TN* 3724, 48 pp., Aug. 1956.

The pressure recovery, mass flow, and axial force of four bodies with nose inlets were measured at Mach numbers between 1.4 and 2.0 and angles of attack of $0^\circ$, $3^\circ$, $6^\circ$, and $9^\circ$. The Reynolds number based on the model inlet diameters varied between 0.4 and 0.8 million. Schlieren photographs of models at $0^\circ$ angle of attack were used for calculation of the external wave drag resulting from the bow shock waves.

The drag coefficients of axially symmetric diffusers operating at the maximum mass-flow rates were calculated from schlieren photographs of the head shock waves and frictional drag considerations. The calculations showed good agreement with the measured values. At reduced mass-flow ratios the agreement was only fair. The results also show that the external drag of axially symmetric ducted bodies at $0^\circ$ angle of attack can be predicted to a good degree of accuracy from theoretical considerations alone, if the entrance flow is supersonic and the point of transition of the boundary layer is known.

In general, it was found that the minimum axial-force coefficient occurred with maximum mass flow through the diffuser, and a small reduction in the mass flow resulted in a large increase in the axial-force coefficient. At reduced mass flows, the effect of mass flow on the total-pressure recovery of a diffuser with a subsonic or a supersonic entrance was small. Changes in the angle of attack from $0^\circ$ to $9^\circ$ generally caused small decreases in the total-pressure recovery. In all cases when the maximum mass-flow decreased with increasing angle of attack, the minimum axial-force coefficient increased by a considerable amount.

From authors' summary

**493. Bromm, A. F., Jr., and Goodwin, J. M., Investigation at supersonic speeds of the variation with Reynolds number and Mach number of the total, base, and skin-friction drag of seven boattail bodies of revolution designed for minimum wave drag,** *NACA TN* 3708, 20 pp., June 1956.

An investigation has been conducted in the Langley 9-in. supersonic tunnel to determine the effect of the variation with Reynolds number and Mach number of the total, base, and skin-friction drag at zero lift of seven boattail bodies of revolution designed for minimum wave drag according to *NACA TN* 2550. The investigation covered a Reynolds number range from approximately $1.0 \times 10^6$ to $10.0 \times 10^6$ at Mach numbers of 1.62, 1.93, and 2.41, respectively. The results show that base drag and, in general, the total drag

increase with increasing values of the ratio of base area to maximum area $B/S_{max}$, although the results reported in *NACA TN* 3054 showed that the wave drag decreased with increasing values of $B/S_{max}$. The laminar skin-friction drag is in agreement with the theoretical predictions used, and, within the Mach number range of these tests, the simple Blasius incompressible theory gives a satisfactory prediction. Except for values of $B/S_{max}$ near 1, the Reynolds number of transition increased with increasing Mach number and, as this ratio approaches 1, this variation is seen to reverse. These variations in Reynolds number of transition with Mach number appear to be associated with the changes in pressure gradient over the rear of the bodies.

From authors' summary

## Turbulence, Boundary Layer, etc.

(See also Revs. 371, 468, 554, 595, 597)

**Book—494. Brun, E. A., Introduction to the study of boundary layer [Introduction a l'étude de la couche limite],** Paris, Gauthier-Villars, 1955, 189 pp. 1.800 fr.

Fundamental boundary-layer theory is presented in a clear and concise way. Treatment includes flow as well as thermal boundary layer, and a short chapter is devoted to diffusion phenomena.

Book may serve as a useful textbook for engineering students and to those not familiar with aerodynamics. However, some incompleteness in subject treatment restrains reviewer from recommendation to a broader audience. No attention has been given to the proven boundary-layer stability theory and the effects of compressibility are only very briefly dealt with. Moreover, bibliography for the more serious readers is completely lacking. Nevertheless, this textbook is very readable as it stands and it gives a well-rounded picture of classical theory.

Y. K. Jan, Holland

**495. Napolitano, L. G., Approximate solution for axially symmetric laminar boundary layers** (in Italian), *Aerotecnica* **36,** 3, 223–233, June 1956.

An approximative method for calculating compressible boundary layers in axisymmetric flow is derived in analogy to the Karman-Pohlhausen method in two-dimensional flow. The approximation is based on the assumption $\delta/r \ll 1$, $\delta^2 dr^{-1}/dx \ll 1$ ($\delta$ boundary-layer thickness), constant Prandtl number, and a linear viscosity-temperature law. The transformation of Dorodnitsyn is applied and polynoms of sixth degree are used for the velocity profiles. The following special cases are considered in detail: (a) zero axial pressure gradient and arbitrary temperature distribution along the wall, (b) nonzero axial pressure gradient, $Pr = 1$ and $T_W = \text{const.}$ The solutions are reduced to simple quadratures. Expressions for the friction number, the Nusselt number of heat transfer, and the recovery factor on heat isolated walls are given.

W. Wuest, Germany

**496. Einstein, H. A., and Li, H., Shear transmission from a turbulent flow to its viscous boundary sub-layer,** 1955 Heat Transfer and Fluid Mech. Inst., Univ. of Calif., Los Angeles, June 23-25, 1955, Pap. 13, 16 pp.

A model for the mechanism of the laminar sublayer of a turbulent mean flow along a smooth wall is proposed which describes the sublayer as being built up and disintegrated periodically. The disturbance was hypothesized to be in the form of a pressure fluctuation, and local pressure measurements were made to support the hypothesis. The experimental program of pressure measurement was conducted in rectangular flume flowing oil at low Reynolds numbers for high viscosity yielding a turbulence system of low frequency and large pressure variation. The experimental results support the hypothesis which yields agreement with other experimental measurements in this field.

R. M. Drake, Jr., USA

**497. Van Driest, E. R., On turbulent flow near a wall,** 1955 Heat Transfer and Fluid Mech. Inst., Univ. of Calif., Los Angeles, June 23-25, 1955. Pap. 12, 16 pp.

Analysis is presented which yields a continuous velocity and shear distribution for turbulent flow near a smooth wall for incompressible fluids. The analysis is based on the mixing-length approach of Prandtl, except that the mixing length is modified to include an exponential damping factor to approximate the damping effect in the proximity of the wall. The result of the analysis fits the measured velocity-profile data for smooth walls. Analysis is also made for rough walls.

R. M. Drake, Jr., USA

**498. Sibulkin, M., Heat-transfer analysis of flow in supersonic nozzles,** 1955 Heat Transfer and Fluid Mech. Inst., Univ. Calif., Los Angeles, June 23-25, 1955, Paper 6, 17 pp.

Paper applies the integrated momentum and energy equations to obtain an analytic solution for flow and heat transfer in a steady turbulent boundary layer in supersonic nozzles with a wall temperature varying in flow direction. Additional assumptions are: constant properties, 1/7-power profiles for the velocity and total temperature, Blasius equation for the wall shear stress, and an extended Reynolds analogy for the heat flow into the wall. The numerical calculations are carried through for several examples and the results are compared with other calculation procedures. The boundary-layer thickness obtained by the present method agrees within 26% with the result of a calculation method with variable properties presented by Tucker. Local heat transfer in the throat of the nozzle varied to approximately the same amount when calculated with various proposed methods.

There is some doubt in the mind of this reviewer whether the boundary layer in the convergent part of a nozzle would be turbulent.

E. R. G. Eckert, USA

**499. Sandborn, V. A., and Braun, W. H., Turbulent shear spectra and local isotropy in the low-speed boundary layer,** *NACA TN* 3761, 34 pp., Sept. 1956.

Measurements of the longitudinal spectra of turbulent intensities and of the Reynolds stress have been made in a boundary layer developing in a fairly strong adverse pressure gradient. The forms of the spectra are compared with the predictions of the Kolmogoroff theory of local isotropy, and considerable discrepancies are found. The nature and cause of these discrepancies are discussed, and three possible causes indicated: (a) the Reynolds number of the turbulent motion is too low, (b) even the smallest eddies receive energy directly from the mean flow, (c) the basic concepts of the theory are at fault.

Reviewer considers that the Reynolds number is too low to expect local isotropy, but points out that this is always true for part of a boundary layer.

A. A. Townsend, England

**500. Murphy, J. S., and Smith, A. M. O., Measurement of wall shearing stress in the boundary layer by means of an evaporating liquid film,** *J. appl. Phys.* **27,** 9, 1097–1103, Sept. 1956.

Authors present results of development of a mass-transfer method for measurement of local wall shear stress in laminar and turbulent flow. Model surface is coated with thin film of suitable liquid and subjected to transverse flow of air. The rate of resulting evaporation is assumed proportional to the skin friction and is determined by measuring the variation in film thickness as a function of time using light enterference fringes. Results of experiments with a flat plate show good agreement with theory.

Method appears to have advantage of simplicity and requires minimum instrumentation, but it gives only shear stress relative to that at a reference station. The absolute value at some point must be determined by other means.

W. DeLapp, USA

**501. Weissberg, H. L., and Berman, A. S., Velocity and pressure distributions in turbulent pipe flow with uniform wall suction,** 1955 Heat Transfer and Fluid Mech. Inst., Univ. of Calif., Los Angeles, June 23-25, 1955, Pap. 14, 30 pp.

Title problem has been investigated using various flow and suction rates, with the aid of hot-wire anemometry and pressure tubes. Charts of mean velocity and turbulence profiles, with and without wall suction, are given. The Reynolds number range is not very wide and the values of the coefficient of friction are higher than would be expected. Reviewer feels that perhaps the sizes of the pressure tubes were a trifle larger than necessary for such work, though, as details have not been given, one cannot be sure. The observations are discussed with reference to a momentum equation derived by authors.

Results are interesting and reviewer feels that the work should be extended to cover much higher Reynolds numbers.

Y. V. G. Acharya, India

## Aerodynamics of Flight; Wind Forces

(See also Revs. 501, 512, 518, 522, 579, 584, 585, 596)

**502. Pivko, S., Pressure distribution and aerodynamic properties of high-speed aircraft. A method for determining the main aerodynamic properties of high-speed aeroplanes,** *Aircr. Engng.* **28,** 330, 259–261, Aug. 1956.

The well-known method of slender airplane theory is applied to a sweptback wing, vertical tail, and elliptical fuselage combination. The results are presented in a manner that can be readily applied to arbitrary forms of wing and vertical tail surfaces.

G. V. R. Rao, USA

**503. Mitsuyasu, A., The effect of wing planform on the downwash behind wings** (in Japanese), *J. Japan Soc. aero. Engng.* **4,** 29, 131–135, June 1956.

Author calculates the downwash on the longitudinal axis behind the wing, whose lift distribution is determined by Weissinger's modification of incompressible lifting-line theory. For straight and sweptforward wings the downwash calculated by assuming flat-sheet trailing vortexes is larger than that obtained by assuming rolled up vortex pair of reduced span. The converse holds for sweptback wing. Wind-tunnel experiments on nontapered wings of aspect ratio 2 give results agreeing fairly well with calculation for straight and 45° sweptforward wings. The observed downwash is much larger for 45° sweptback wing. I. Tani, Japan

**504. Nielsen, J. N., Quasi-cylindrical theory of wing-body interference at supersonic speeds and comparison with experiment,** *NACA Rep.* 1252, 56 pp., 1955.

Report consists essentially of a collection of the results previously reviewed in AMR **6,** Rev. 565 and AMR **7,** Rev. 3981. The main addition is the presentation of further theoretical details and results for the case of circular body at incidence.

J. J. Mahoney, Australia

**505. Weissinger, J., New developments in airfoil theory in incompressible flow** (in German), *Z. Flugwiss.* **4,** 7, 225–236, July 1956.

The various theorems and numerical methods for calculating the lift distribution over airfoils in incompressible, inviscid, and steady flow are summarized. From author's summary

**506. Lindsey, W. F., The flow past an unswept- and a swept-wing-body combination and their equivalent bodies of revolution at Mach numbers near 1.0,** *NACA TN* 3703, 18 pp., June 1956.

Tests utilizing the schlieren method of flow photography have been conducted to provide a comparison of the complete flow fields past an unswept- and a swept-wing-body combination and the flow fields past their equivalent bodies of revolution at Mach numbers around 1.0. The results indicate that the shock growth and positions on the wing-body combinations were closely reproduced in the flow past the equivalent body. From author's summary

**507. Niblett, L. T., The geared elevator tab and tail-unit stiffness requirements,** *Aero. Res. Counc. Lond. Rep. Mem.* 2848, 18 pp., 1955.

The effect of a flexible, geared, elevator tab upon the validity of the stiffness criteria for tail units and rear fuselages is studied. The distortions of a hypothetical, semi-rigid tail unit under the air loads induced when the elevator is displaced are calculated for various arrangements of tab and forward aerodynamic balance of the elevator.

It is found that a geared elevator tab covering only a fraction of the elevator span may lead to large tip distortions and appreciably reduce the control effectiveness of the elevator if it is placed near the inboard end. A torsional-stiffness criterion for tabs is proposed from the consideration of the distortions of the tab and the effect upon elevator hinge movement.

From author's summary by G. B. White, USA

**508. Lovell, P. M., Jr., and Parlett, L. P., Transition-flight tests of a model of a low-wing transport vertical-take-off airplane with tilting wing and propellers,** *NACA TN* 3745, 30 pp., Sept. 1956.

Paper describes free-flight tests in the Langley full-scale tunnel. The model was of a four-engine turboprop transport of conventional layout except that the wings could be rotated relative to the fuselage from about 90° to the horizontal for the hovering condition to the usual position for normal flight. Control in hovering and low-speed flight was obtained by deflection of full span flaps and by variation of pitch of the propellers. Some of the stability and control characteristics were investigated in the transition from hovering to normal flight. The results demonstrate a readiness to uncontrollable pitch-up in the transition condition unless the wing pivot and C.G. are well forward; and for certain conditions of airspeed and fuselage attitude the Dutch roll oscillation was found to be lightly damped. A. D. Young, USA

**509. Huston, W. B., and Skopinski, T. H., Probability and frequency characteristics of some flight buffet loads,** *NACA TN* 3733, 52 pp., Aug. 1956.

Power spectra, probability distributions of zeros and peaks, counts of zeros and peaks, moments, etc., are given for wing and tail vertical shear loads at root section in pull-up to stall maneuvers. Measurements are from flight tests of unswept wing and tail fighter at Mach numbers 0.46 and 0.74. A high-pass numerical filter is constructed for operation on data to separate maneuver from buffet loads. Chi square tests at 0.05 level of significance indicate sample of wing loads is from a normal distribution. Maximum sample variance is 220 with mean 6.5 lbs. Tail loads are not normal at this level of significance. Tukey's formulas are used to compute spectra. Rice's formulas give distribution of expected zeros and peaks, using both ratio of counts of zero to peaks of the time signal, and integrated moments of the output spectrum.

K. D. Saunders, USA

**510. Grzedzielski, A., Eccentric landing with heavy masses at the wing tips,** *J. aero. Sci.* **23,** 7, 653–659, July 1956.

It is shown that, with large outboard loads, the semiwheel tread may be less than the radius of gyration $i$ in roll, and an eccentric landing can result in overloadings of gear relative to the symmetric design loading. When the semitread is sufficiently smaller than $i$, then also the initial contact gear will be unloaded before absorbing its design energy dissipation and the aircraft will have initial rocking in the landing roll. The simple impulse momentum theory is used on a two-particle equivalent roll-drop system to set up the equations of motion. They are solved and three cases are compared, including the symmetrical one. The several charts presented show, among other things, that overloads of the order of magnitude of 50% over the symmetric case must almost certainly be anticipated. It is also indicated that eccentric landings with

large outboard loading and resonant gear impacts will result in increased tip accelerations and corresponding overstressing.

M. G. Scherberg, USA

**511. Lopez, A. E., and Dickson, J. K., The effects of compressibility on the upwash at the propeller planes of a four-engine tractor airplane configuration having a wing with 40° of sweepback and an aspect ratio of 10,** *NACA TN* 3675, 38 pp., July 1956.

An investigation has been conducted in which upflow angles were measured along the horizontal center lines of the propeller planes of a semispan model representing a multiengine airplane with tractor propellers. The wing had 40° of sweepback, an aspect ratio of 10, and a taper ratio of 0.4. Tests were conducted at Reynolds numbers of 2, 4, 6, and 8 million at low Mach numbers, and a Reynolds number of 2 million at Mach numbers from 0.25 to 0.92.

In addition, the upflow was measured with the nacelle alone to evaluate the theoretical method for predicting the upwash induced by the nacelle. The tests with the nacelle alone were conducted at a Reynolds number of 4 million at a Mach number of 0.123, and at a Reynolds number of 2 million at Mach numbers from 0.60 to 0.92.

The results indicate that, for Mach numbers up to 0.60, the upwash angles can be predicted accurately by the available theoretical methods. At Mach numbers above 0.60, the experimental values were less than those predicted by theory and this difference increased with increasing Mach number.

From authors' summary

## Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 388, 446, 510)

**512. Runyan, H. L., and Woolston, D. S., Method for calculating the aerodynamic loading of an oscillating finite wing in subsonic and sonic flow,** *NACA TN* 3694, 76 pp., Aug. 1956.

Authors give a method for determining the air forces on oscillating wings of general planform. Some of the concepts used are similar to those developed by Falkner in his steady lifting-surface theory [*Aero. Res. Counc. Lond. Rep. Mem.* 1910]. Authors use the acceleration potential in preference to the velocity potential method of approach which was developed by reviewer to solve similar problems [AMR **6,** Rev. 3847].

Wing loading is given in the form of a series with unknown coefficients. These coefficients are defined by a set of simultaneous equations which they must satisfy and which must be solved. Authors apply their method to rectangular and delta wings and compare results with those obtained by the use of some other existing theories. Some numerical examples are given.

Paper should be of considerable interest to those concerned with the estimation of flutter and stability derivatives.

W. P. Jones, England

**513. Aeroelastic problems of low aspect ratio wings,** *Aircr. Engng.:* **Part I, Thomann, G. E. A., Structural analysis, 28,** 324, 36–42, Feb. 1956; **Part II. Woodward, F. A., Aerodynamic forces on an elastic wing in supersonic flow, 28,** 325, 77–81, Mar. 1956; **Part III, Leyds, J., Aerodynamic forces on an oscillating delta wing, 28,** 326, 119–122, Apr. 1956; **Part IV, Leyds, J., Application of the structural and aerodynamic matrices to the solution of the flutter problem, 28,** 327, 166–167, May 1956; **Part V, Farbridge, J. E. F., Woodward, F. A., and Thomann, G. E. A., Application of the structural and aeroelastic matrices to the solution of steady-state aeroelastic problems, 28,** 328, 196–198, June 1956.

In the first three parts, the derivation of the matrixes of, respectively, the elastic, the aerodynamic steady flow, and the aerodynamic nonsteady flow influence coefficients is given.

In part **I**, the method of Levy [AMR **7,** Rev. 769] is followed, simplified by grouping points of a straight beam together and forming submatrixes.

In part **II**, the loading on each small area is built up by superposing solutions obtained from linearized supersonic control surface theory [AMR **4,** Rev. 3310].

In part **III**, lift and moment coefficients are derived using methods given in AMR **6,** Rev. 534 for subsonic, and in AMR **5,** Rev. 481 for supersonic flow. These methods are modified to give coefficients at specific wing stations rather than those per unit span. Natural modes of vibration are found following Scanlan and Rosenbaum [AMR **4,** Rev. 4574], and the generalized aerodynamic forces are determined.

In the latter two parts specific problems are solved with the aid of the derived matrixes.

Part **IV** gives the solution of the Lagrange flutter equations by means of analog and digital computer methods.

In part **V**, the derivation by matrix iteration of the steady-state loading is indicated. A simple test is developed to check the convergence of this method. Otherwise the loading can be found by matrix inversion. The calculation of the elastic stability derivatives, the internal stresses, aileron reversal, and wing divergence is briefly indicated.

The methods given in these papers were derived for use on a particular delta wing design. Numerous assumptions had to be made to make the methods practicable from an engineering standpoint. As pointed out in part V, the results have a low degree of accuracy. No comparison is given with results obtained by other means. However, the methods are very attractive because of the clearness of matrix notation and the powerful combination of this with digital computing.

M. Botman, Canada

**514. Clevenson, S. A., and Widmayer, E., Jr., Experimental measurements of forces and moments on a two-dimensional oscillating wing at subsonic speeds,** *NACA TN* 3686, 28 pp., June 1956.

Experimental results of lifts and moments about the quarter chord of a two-dimensional wing at subsonic Mach numbers are presented. A comparison of the experimental magnitude of the lift vector with the theory as given by Dietze showed good agreement. Comparisons of the moments and the quadrature component of lift with theory indicated that some refinements in the testing technique are necessary for the experimental determination of these quantities in the transonic range.

From authors' summary

**515. De Vries, G., Safeguards against flutter of airplanes,** *NACA TM* 1423, 94 pp., Aug. 1956.

Report is a compilation of practical rules, derived at the same time from theory and from experience, intended to guide the aeronautical engineer in the design of flutter-free airplanes. Rules applicable to the wing, the ailerons, the flaps, tabs, tail surfaces, and fuselage are discussed successively.

From author's summary

**516. Miles, J. W., The compressible flow past an oscillating airfoil in a wind tunnel,** *J. aero. Sci.* **23,** 7, 671–678, July 1956.

The disturbance produced by an oscillating airfoil in a two-dimensional supersonic wind tunnel is exhibited explicitly in terms of image fields and guided waves. The corresponding subsonic problem leads to an integral equation, the kernel of which is expanded in guided waves. The supersonic results are applied to the calculation of the longitudinal stability derivatives associated with a low-frequency pitching oscillation. The results seem to exonerate the wall interference from being responsible for the discrepancy between theory and experiments of single-degree-of-freedom pitching instability. It is pointed out that the guided-wave formulation may be of some interest in the analysis of cascades of airfoils.

From author's summary by H. P. Liepman, USA

**517. Broadbent, E. G., Aeroelastic problems in connection with high-speed flight,** *J. roy. aero. Soc.* **60,** 547, 459–475, July 1956.

A review is given of developments in the field of aeroelasticity during the past ten years. The effect of steadily increasing Mach number has been two-fold: on the one hand, the aerodynamic derivatives have changed, and in some cases brought new problems; on the other hand, the design for higher Mach numbers has led to thinner airfoils and more slender fuselages for which the required stiffness is more difficult to provide. Both these aspects are discussed, and various methods of attack on the problems are considered. The relative merits of stiffness, damping, and massbalance for the prevention of control surface flutter are discussed. A brief mention is made of the recent problems of damage from jet efflux and of the possible aeroelastic effects of kinetic heating. From author's summary

**518. Rodden, W. P., An aeroelastic parameter for estimation of the effects of flexibility on the lateral stability and control of aircraft,** *J. aero. Sci.* **23,** 7, 660-662, July 1956.

Effects of flexibility on lateral stability are accounted for by adding a term proportional to the twist angle of the wing tip to the equation for rolling moment. The twist, in turn, is proportional to the aerodynamic loading. Methods of calculating the proportionality factor are discussed and examples given. Author notes that effects of flexibility on other components can be treated in a similar manner. L. H. Schindel, USA

**519. Broadbent, E. G., and Mansfield, O., Aileron reversal and wing divergence of swept wings,** *Aero. Res. Counc. Rep. Mem.* 2817, 26 pp., 1954.

A method of solution for the aileron reversal speed of a swept wing (with emphasis on sweepback) is developed on the lines of strip and semirigid theories. The following parameters are investigated (i.e., effect on aileron reversal and divergence speeds): (1) The degree of sweep, (2) wing torsional and flexural stiffness, (3) wing planform, (4) aileron planform. Families of curves are given for extended variations of these parameters which may be used for the direct estimation of the reversal speed of a given wing.
From authors' summary by S. Lampert, USA

**520. Schmidt, R., Vibration of compressor blades in jet engines** (in German), *Technik* **11,** 7, 479-486, July 1956.

## Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 462, 520, 571, 581, 594)

**521. Sohn, R. L., An analysis of the performance of an axial-flow compressor at low Reynolds number,** *J. aero. Sci.* **23,** 8, 741-746, 791, Aug. 1956.

Author shows that existence of "critical" Reynolds number for compressor cascades is related to inability of separated laminar layer to reattach by turbulent diffusion downstream of point of minimum pressure. Experimental data of several investigators are interpreted from this point of view. A theory is formulated, based on calculated boundary-layer parameters and empirical data for cascades, to predict critical Reynolds number. Decent agreement with experiment is obtained for low values of incidence.
A. H. Shapiro, England

**522. Stenning, A. H., Kriebel, A. R., and Montgomery, S. R., Stall propagation in axial-flow compressors,** *NACA TN* 3580, 83 pp., June 1956.

Theory for subject phenomenon is developed to include the effects of finite blade chord and boundary-layer response to changes in angle of attack. Experimental results are also presented which show fair agreement with the theoretical predictions of the propagation velocities. B. Smilg, USA

**523. Senoo, Y., A comparison of regenerative-pump theories supported by new performance data,** *Trans. ASME* **78,** 5, 1091-1102, July 1956.

Paper and associated discussions give known various descriptive explanations of regenerative-pump operating principles. Limited experimental data on geometry of pumping channel demonstrate consistent performance tendencies when considered in terms of theories. Reviewer believes paper demonstrates all theories proposed to date are semi-empirical and require additional test performance data to provide a useful guide for pump designers.
R. G. Folsom, USA

**524. Novik, D., Some linear dynamics of two-spool turbojet engines,** *NACA TN* 3274, 35 pp., June 1956.

General equations for the linear responses of inner- and outer-spool speed to change in turbine-inlet temperature and exhaust-nozzle area are derived and evaluated from hypothetical two-spool-engine characteristics at design speed. The resultant equations of response are corroborated with experimental data. At design speed the response of inner-spool speed to turbine-inlet temperature approximated a first-order lag specified by the time constant of the inner spool. The outer-spool speed response to turbine-inlet temperature was found experimentally to be identical with the response of inner-spool speed, in that it approximated a first-order lag specified by the inner-spool time constant. The analytically derived response of outer-spool speed to turbine-inlet temperature was a lead second-order lag that could result in the experimentally determined response by cancellation of terms in the response equation. With respect to changes in exhaust-nozzle area, the design-speed response of the outer-spool speed approximated a first-order lag specified by the outer-spool time constant, whereas the inner-spool speed response approximated a second-order lag, but of negligible amplitude. From author's summary

**525. Hegetschweiler, H., and Bartlett, R. L., Predicting performance of large steam turbine-generator units for central stations,** ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 56-SA-52, 8 pp. + 3 tables + 29 figs.

The purpose of this paper is to provide the power industry with an up-to-date method for predicting the performance of large steam turbine-generator units. The efficiency calculation method given has been adjusted carefully to show a true comparison between machines of different types, sizes, steam conditions, reheat and non-reheat, etc. The level of performance obtained by use of this method is judged to be the highest justifiable for prediction purposes at the present state of the art. Figure 1 shows the correlation of the method with recent representative test results.

Based upon the performance calculation method presented in this paper, relative heat-rate curves have been prepared comparing the performance of various turbine-generator units at normal name-plate rating. A complete heat-balance diagram and an efficiency calculation example are included which illustrate the use of the method.
From authors' summary

**526. Whyte, R. R., The influence of the gas-turbine axial-flow aero-engine on blade manufacturing methods,** *Instn. mech. Engrs.*, Prepr., 14 pp., 1956.

Paper reviews, very briefly, the traditional methods of manufacture of steam-turbine blades, comments on the different technical requirements of blades for gas turbines, and surveys the history of some of the developments in manufacturing methods of blades for gas turbines with particular reference to methods developed for the production of blades for an early series of axial-flow jet engines.

As by far the larger proportion of blades in an axial-flow aero-engine are compressor blades, paper is largely concerned with the development of compressor-blade manufacturing methods. Paper concludes with a short appreciation of the past and future competitive positions of the precision-forged and machined stainless-steel compressor blade. From author's summary

**527. Marinescu, M., and Apostol, P., Method of calculation and design of a diffusor of dynamic type for direct radiation** (in Rumanian), *Acad. Repub. pop. Rom. Comun.* **6,** 1, 105-113, 1956.

**528. Wick, R. S., The effect of vehicle structure on propulsion system dynamics and stability,** *Jet Propulsion* **26,** 10 (part 1), 878–887, Oct. 1956.

It is shown that the structure of a test stand or airframe may significantly modify the dynamical properties of a rocket engine. Transfer functions describing some of these effects are developed and some general conclusions are drawn for the case of a monopropellant rocket, in terms of the natural frequency of the vehicle structure, the combustion lag, and the distribution of masses between various portions of the vehicle. J. R. Sellars, USA

**529. Stulen, F. B., Structural design of high-speed propellers,** *SAE Trans.* **63,** 429–441, 1955.

Various structural problems encountered in the design of high-speed turboprop propellers are discussed in this paper.

Formulas for a number of design factors are also given here. These include: Blade efficiency, power capacity, advance/diameter ratio, limiting tip speed, periodic lift, propeller normal force and moment.

Paper also describes two types of vibration occurring with turboprop installations: (1) first-ordered aerodynamically excited vibration; (2) subsonic stall flutter. Author shows how these vibrations may be accurately predicted and controlled by proper design of the propeller blades. From author's summary

## Flow and Flight Test Techniques

(See also Revs. 449, 488, 528, 568, 598)

**530. Livesey, J. L., The behavior of transverse cylindrical and forward facing total pressure probes in transverse total pressure gradients,** *J. aero. Sci.* **23,** 10, 949–955, Oct. 1956.

Paper is concerned with the effect of construction details on the errors of the cantilever pitot cylinder and the conventional pitot tube. For negligible dynamic pressure error, tests of several sizes of cylinders in a thick boundary-layer showed that the stagnation hole should be several diameters deep and located two diameters from the free end, as found by others [cf. Winternitz; AMR **9**, Rev. 1211]. The effect of transverse gradient is shown to cause an error directly proportional to the nondimensionalized true pressure gradient. However, expressed as an outward displacement of the hole center, the error could be indicated as a shift of 0.09 cylinder diameters, in the range $0.2 < (D/q)(dq/dy) < 1.2$. When the hole is closer to a wall than 0.2 cylinder diameters, a wall proximity error was noted, resulting from a horseshoe vortex, such as studied by Hawthorne [AMR **8**, Rev. 1419].

For pitot-type probes, author finds disagreement with Young and Maas [*Aero. Res. Counc. Rep. Mem.* 1770, 1936] for the effective probe displacement due to the gradient; this is shown to depend upon tip shape. For square cut and hemispherical noses, results similar to Young and Maas were found. Conical-nosed pitots with sharp lips had negligible gradient effect.

Reviewer suggests that cylindrical pitot is incorrectly, or at least not clearly, described as a "transverse cylindrical" probe. This name is usually taken to indicate one spanning the conduit from wall to wall. The type reported on is more usually identified as the "cantilevered pitot tube." J. Robertson, USA

**531. Newman, J. L., Waddell, C., and Sauder, H. L., A flowmeter for measuring subsurface flow rates,** *J. Petr. Technol.* **8,** 7, 49–52, July 1956.

An instrument capable of measuring subsurface flow rates is described. The instrument is self-contained and may be run on piano wire line. It detects flow by means of an impeller suspended between two torsion wires. The force of the well fluid striking the impeller causes the impeller to rotate, exerting a torsional force to the wires. This force is determined by recording the angle of rotation of the impeller on film, using a battery-driven, clock-controlled camera. The impeller is sensitive to flow in either direction and the same instrument can be used to measure injection as well as production rates. Changes in direction of flow, such as might be caused by thief zones, are measurable and are indicated by a reversal of the direction of rotation of the impeller. Adjustment of the sensitivity of the instrument to measure a wide range of flow rates is accomplished by the use of different size torsion wires. An umbrella-type fluid trap, which contacts the casing or wellbore, diverts the flow through the flow tube. The fluid trap remains closed while running in the hole and can be opened at any point in the well. The instrument with the trap closed is 1¼-in. OD and may be run through 2-in. tubing. Successful flow profiles have been made on wells with flow rates ranging from 60 B/D to 4000 B/D at surface pressure up to 4500 psi. The instrument is designed for high-pressure and high-temperature operations. From authors' summary

**532. Haskell, C. A., Mass flowmeter summation system,** *Aero. Engng. Rev.* **15,** 7, 54–57, July 1956.

A measurement system for total fuel flow in multiengine aircraft, as well as for fuel flow to each engine, is presented. From author's summary

**533. Kamimoto, G., On wind-tunnel interference and wall boundary-layer effects in the airfoil cascade** (in Japanese), *Trans. Japan Soc. mech. Engrs.* (3) **22,** 117, 306–311, May 1956.

Using the method of conformal mapping, the effect is theoretically determined of the wind-tunnel wall on the turning angle of flow past a cascade of airfoils. The flow is assumed irrotational, and the airfoil is represented by a concentrated vortex at the quarter chord point. Numerical results are given for a number of cascade arrangements. The effect due to the boundary layer along the tunnel wall is also considered. I. Tani, Japan

**534. Kamimoto, G., On the method of calculating the wind-tunnel interference in the cascade test** (in Japanese), *Trans. Japan Soc. mech. Engrs.* (3) **22,** 117, 312–317, May 1956.

In this paper, the result of the preceding paper is used to calculate the pressure distribution on each airfoil in the cascade. Numerical example is worked out for the cascade of five NACA 6409 airfoils. I. Tani, Japan

**535. Wright, R. H., and Ward, V. G., NACA transonic wind-tunnel test sections,** *NACA Rep.* 1231, 38 pp., 1955.

If the working section of a wind tunnel has solid boundaries, satisfactory model testing at free-stream Mach numbers close to unity is impossible because of choking; if the boundaries are open, choking does not occur, but the flow is usually less steady, and, moreover, the interference corrections remain uncertain at near-sonic speeds. For many years these difficulties severely limited the utility of wind tunnels for transonic investigations. Of the various schemes suggested to overcome this limitation, the principle of that described in the present report (first issued in 1948) is now generally accepted as the most satisfactory, and has been adopted in many wind tunnels. The work described thus represents an important contribution to experimental aerodynamics, for which both the authors and the NACA should be congratulated.

The scheme exploits the fact that the solid blockage effects (which are usually the dominant inteference effects at transonic speeds) are of opposite sign in working sections with solid and open boundaries, by using a partly-solid and partly-open boundary to produce substantially zero blockage. An approximate theory is developed for the solid blockage at subsonic speeds for a body supported on the axis of a tunnel of circular cross section with openings in the form of uniform slots running parallel to the flow, and distributed uniformly round the periphery. The theory indicates that the ratio of the open portion of the periphery to the total periphery for zero blockage is independent of Mach number, and decreases as the number of slots is increased, having a value of about ⅛ for ten slots.

Experiments were made at zero incidence on a prolate spheroid (about 8½% blockage) in a 12-in. diam slotted tunnel designed on the basis of the theory, and on a prolate spheroid fitted with a rectangular wing (about 2% total blockage) in an octagonal tunnel of 12-in. effective diameter. The pressure distributions on these models were found at subsonic speeds to agree well with those measured on the same models in much larger tunnels where the blockage was very small. Even with these rather large values of the blockage, reasonable, although poorer, agreement was also obtained at higher Mach numbers up to 1.1.

The longitudinal slots were continued downstream of the working section to a point in the diffuser where the cross-sectional area of the tunnel had increased by 20% and the slotted region of the tunnel was surrounded by an airtight chamber. With this arrangement it was found that supersonic flow could be produced in the working section at a Mach number which could be adjusted by changing the pressure ratio applied between the upstream and downstream ends of the tunnel. With the uniform slots used, however, the distribution of Mach number along the working section deteriorated when the Mach number exceeded about 1.1. The power needed to drive the slotted tunnel at a particular Mach number was found to be considerably greater than that for a closed tunnel of the same area. D. W. Holder, England

**536. Mirels, H., Attenuation in a shock tube due to unsteady-boundary-layer action,** *NACA TN* 3278, 60 pp., Aug. 1956.

The problem of the attenuation of a shock wave in a long tube is becoming very important because of the use of the shock tube for high Mach number testing. This paper, which presents a theoretical treatment and experimental data, will be of great interest even though the data are for Mach numbers below 2. The theoretical treatment is also limited to low Mach numbers because of simplifying assumptions.

Attenuation is attributed to waves generated by the buildup of the boundary layer behind the shock. This is considered equivalent to mass addition at a rate determined by the normal velocity at the edge of the boundary layer. The effect on the shock is found by solving linearized equations.

The theory is applicable when boundary-layer thickness is small compared to the radius. For a thick boundary layer, the theory of Trimpi and Cohen [AMR **8**, Rev. 3508], which assumes the waves are generated by distributed friction, must be used. For weak shocks both theories give similar results.

W. Squire, USA

**537. Fetter, R. A., Jr., A design of electrical control heaters for operation with a supersonic, blow-down wind tunnel,** Defense Research Lab., Univ. Texas, AFOSR-TN-56-188, 76 pp., June 1956.

Development of continuous flow heater for $M = 5$, 6-in. × 6-in. tunnel for 315 psia stagnation pressure, stagnation temperatures to 1400 F, air mass flows of 0.17 slugs/sec for 2 minutes, with emphasis on fast response and simplicity.

A. E. Bryson, USA

**538. Hartwig, W. H., Theory, design, and performance of a 420 kw electrical heater for automatic control of stagnation temperature in a blow-down wind tunnel,** Defense Research Lab., Univ. Texas, AFOSR-TN-56-163, 89 pp., June 1956.

Large storage heater, preheated by gas-fired burners, supplied most of heat while an auxiliary 440-volt, 3-phase, a-c electrical heater makes up difference. Fraction of a cycle during which heater current flows is controlled by feedback signal from thermopile which, either manually or by servomotor, phase shifts thyratron grid voltage which fires ignitron in series with heater. Control to ± 3 F from room temperature to 1400 F is achieved for 2-minute running time. A. E. Bryson, USA

## Thermodynamics

(See also Revs. 448, 450, 480, 525, 561, 565, 567, 581)

**Book—539. Prigogine, I., Introduction to thermodynamics of irreversible processes,** Springfield, Ill., Charles C. Thomas, 1955, ix + 115 pp. $4.75.

Booklet describes in detail the principles of this subject. As can be expected from the author, who has contributed a great deal of the recent advances on the subject, the book is full of interesting sidelights and is lucidly written. It is a volume in the series of "American lectures in biochemistry and biophysics," and shows in different places how the thermodynamics of irreversible processes can be applied to biological problems. The tenor of the book is chemical rather than physical.

Reviewer found it a pity that the author did not discuss the application of thermodynamics of irreversible processes to thermoelectric phenomena, and that he did not discuss, or even mention, the modifications which have to be made to the Onsager relations if magnetic fields are present. However, these are very minor points and this volume should be a very good introduction to this subject for anybody who wants to find out what has been achieved since the war in this field, and who does not have the time to read de Groot's more extensive monograph. The printing of the volume seems to have been delayed rather long, and, as a result, the bibliography is about two years out of date.

D. ter Haar, England

**540. Miller, D. G., Thermodynamic theory of irreversible processes—I. The basic macroscopic concepts,** *Amer. J. Phys.* **24**, 6, 433-444, Sept. 1956.

The foundations of the thermodynamic theory of irreversible processes are presented in macroscopic terms. The concept of entropy production in systems with gradients is discussed in relation to classical thermodynamics and to what new hypotheses are necessary. The entropy production is computed in some simple cases, and it is found that its factors can be related to well-known linear laws such as Ohm's. It is shown on experimental grounds that the linear laws must be generalized in complex cases involving interacting flows. Further appeal to experiment shows that the Onsager relations must be valid. The range of validity of the theory is discussed. From author's summary

**541. Cockshutt, E. P., Turbojet cycle analysis: the effects of liquid injection at several points in the cycle,** *Nat. aero. Establ. Canad.* LR 164, 8 pp. + 8 figs. + 1 appendix, Apr. 1956.

An analysis is made of the effects of injecting a liquid in a turbojet cycle, either before the turbine or in the tailpipe. Equations are given in linear differential form for the resultant changes in peak cycle temperature, tailpipe pressure, and turbine pressure ratio, and curves presenting results for typical operating conditions are presented.

Author draws following conclusions from analysis: (1) Effects of pre-turbine liquid injection and tailpipe injection are quite different. (2) In both cases the controlling factor is the latent heat of vaporization of the injected liquid. (3) If kerosene is injected ahead of the turbine, the engine must be overheated if operated with a fixed propelling nozzle. (4) If kerosene is injected in the tailpipe, the effects of mass addition and evaporative cooling roughly cancel each other, and no overheating occurs.

Author assumes that the compressor has a vertical characteristic; this greatly simplifies the analysis. In private communication with reviewer, author shows that effect of nonvertical compressor characteristics on peak cycle temperature are likely to be small, but if one is interested in tailpipe pressure response, it may prove necessary to consider the effects of nonverticality of compressor characteristic. Reviewer feels simplification is justified for the sake of clarity in presenting paper, and can ordinarily be shown to lead to errors which are not serious.

R. L. Mela, USA

**542. Touloukian, Y. S., The concept of entropy in communication, living organisms, and thermodynamics,** *Purdue Engng. Exp. Sta. Res. Bull.* 130, 66 pp.

**543. Travers, S., Resistance of air and kinetic theory of gases at high altitude** (in French), *Mem. Artill. fr.* **30**, 1, 167–269, 1956.

Above 100 km, the mean free path of air is generally large compared with projectile dimensions and the air resistance no longer obeys the laws established in a normal atmosphere. For the calculation of this resistance, Knudsen's hypothesis of emission after adsorption is less inadequate than that of Schweikert who assumes elastic molecular reflection from a moving boundary.

M. Travers shows that air resistance cannot modify the trajectory or performance of an ionospheric engine but that it assures the destruction of small bodies at very high altitudes, e.g., eventually that of an artificial satellite descending below 200 km.

Three appendixes of a general and mathematical nature are devoted, respectively, to (a) probability functions; (b) ionization, evaporation, and formation of radioactive material by thermal agitation; (c) entropy and probability. These addenda are useful for calculations of resistance from the Maxwell distribution law for artificial satellites. Furthermore, on the basis of helium evaporation, the following hypothesis is seen to be justified: the air composition, except for dissociation, is close to that in the neighborhood of the sun.

The addenda relate the notion of entropy to (a) approximations of probability functions, and to (b) the latest theories of cosmical evolution.

Ten tables of numerical data are presented in order to assist with the calculations of chemical kinetics, ionization, formation of radioactive material, and other parameters.

Use of the kinetic theory of ideal gases for non-equilibrium and anisotropic states has provided us with the mathematical means for studies by modern physicists and ballisticians who are interested in exploring or even surpassing the highest terrestrial atmosphere.

From author's summary by S. S. Penner, USA

**544. Van Itterbeck, A., Lambert, H., and Forrez, G., Measurements on the second virial coefficient of nitrogen between 90 and 65°K with use of ultrasonics,** *Appl. sci. Res.* (A) **6**, 1, 15–20, 1956.

Measurements are carried out on the second virial coefficient of nitrogen gas between 90 K and 65 K using an indirect method based on the velocity of sound as a function of pressure. An equation for this coefficient as a function of temperature is derived. This equation is valid between 65 and 150 K. Also, above 150 K good agreement is found with the values obtained by Kamerlingh Onnes and van Urk. Using a Lennard-Jones potential, the second virial coefficient was calculated with the method of Hirschfelder. Good agreement with experimental values was found.

From authors' summary

**545. Tschinkel, J. G., Calculation of a Mollier diagram for the decomposition products of aqueous hydrogen peroxide solutions of 90 weight per cent $H_2O_2$ content,** *Jet Propulsion* **26**, 7 (part 1), 569–571, 575, July 1956.

An enthalpy-entropy (Mollier) diagram was designed for the products of decomposition of 90 weight per cent aqueous $H_2O_2$ solution. The method of calculation is described. Metric technical units were used. The pressure range covered is 0.1 to 100 kg/cm². Reference state is 0 C temperature, one kg/cm² pressure, liquid water, and gaseous oxygen.

From author's summary

**546. Fano, L., Hubbell, J. H., and Beckett, C. W., Compressibility factor, density, specific heat, enthalpy, entropy, free-energy function, viscosity, and thermal conductivity of steam,** *NACA TN* 3273, 61 pp., Aug. 1956.

The tables of thermal properties of steam that have been prepared in an NBS-NACA series have been grouped together here. They include, for the real gas, compressibility factor, density, specific heat at constant pressure, enthalpy, entropy, free-energy function, viscosity, and thermal conductivity. For the ideal gas, specific heat, enthalpy, entropy, and free-energy function are given. For the tables given in dimensionless form, conversion factors to some frequently used units are given.

The tabular entries for the compressibility factor and density are for pressures ranging from 1 to 300 atm. The temperatures cover the range from 380 K, or just above condensation, to 850 K. The tabular entries for specific heat, enthalpy, entropy, and free-energy function are for pressures ranging from 1 to 100 atm and for temperatures up to 850 K. The viscosity and thermal conductivity are tabulated as a function of pressure.

From authors' summary

**547. Krupkowski, A., On substitute pressure in the isothermal process,** *Bull. Acad. Polonaise Sci.* Cl. IV **4**, 1, 51–55, 1956.

Author introduces expression "$\phi^0_{PT}$ = exponent $\left[(1/RT)\int_1^P V dP\right]$ which denotes the substitute pressure corresponding to the work necessary for changing the volume of one mole of a homogeneous phase in any physical state during an isothermal process."

Value of substitute pressure is obtained by comparing graphs for isotherm of a homogeneous phase with that of an ideal gas. Integrating the expression $\phi^0_{PT}$ the lower limit is $P = 0$ for real gases, while in calculating the substitute pressure the lower limit is $P = 1$ atmosphere.

Author proceeds with calculations for real gases and condensed substances and ends up with determining, mathematically, the value of thermodynamic functions in respect to substitute pressure.

Space does not permit to carry out solutions for some 20 odd equations.

W. Green, USA

**548. Greinacher, V. H., Pressure in ultracentrifuges** (in German), *ZAMP* **7**, 2, 152–156, 1956.

Compressibility coëfficient $k$ of liquid having mass $m$ and rotating uniformly in a cylindrical ultracentrifuge can be calculated from the change of its volume $\Delta V$ by using a simplified formula $k = 4m\omega^2 r^2 \Delta V$. Molecular weight $M$ of gas can be determined from pressure drop in the axis of rotating cylindrical vessel. Author derives precise equation for this pressure $p_A/p_0 = (e^a - 1)/a$ where $a = M\omega^2 r^2/2RT$ and recommends measuring it from the change of electrical potential $V$ which would be necessary to cause a spark of a given length $p_A/p_0 = V_A/V_0$.

O. Mastovsky, Czechoslovakia

**549. Beck, A., Jaeger, J. C., and Newstead, G., The measurement of the thermal conductivities of rocks by observations in boreholes,** *Austr. J. Phys.* **9**, 2, 286–296, June 1956.

Methods of measuring thermal conductivity of rock strata by means of bore holes are discussed. Limited data are presented. The proposed techniques should provide data with an accuracy of probably no better than 10 – 15%.

R. J. Mindak, USA

**550. ter Haar, D., and Heaves, A., On the thermal conductivity and thermoelectric power of semi-conductors,** *Advances in Physics* **5**, 18, 241–269, Apr. 1956.

**551. Vos, B. H., Measurements of thermal conductivity by a non-steady-state method,** *Appl. sci. Res. (A)* **5**, 6, 425–438, 1956.

Paper presents a discussion of thermal conductivity measurements based on the fact that, for unsteady radial heat flow, a relation can be found between the conductivity and rate of temperature rise in a sample fitted with a steady heat source. A discussion

of error-contributing factors and limitations of the method, and some experimental measurements, are included. Reviewer believes method should have practical use for materials of relatively low thermal diffusivity, i.e., non-metals.

D. L. Doughty, USA

**Book—552. Frenkel, J., Kinetic theory of liquids,** New York, Dover Publications, Inc., 1955, xi + 488 pp. $1.95 (paperbound). Reprint of 1946 edition.

**553. Curran, H. M., Fresh water extracted from salt water: Is the freezing method the best?,** *Refrig. Engng.* **63,** 9, 45–56, Sept. 1955.

## Heat and Mass Transfer

(See also Revs. 369, 370, 459, 497, 541, 551, 553, 574, 580)

**554. Bromberg, R., A note on the effects of gas dissociation on boundary-layer heat transfer,** *J. aero. Sci.* **23,** 10, 976–977 (Readers' Forum), Oct. 1956.

Paper considers very high velocity gas flow over a body where dissociation and recombination in the boundary layer can affect the heat transfer. In the energy equation, the rate of energy transfer per unit area by all diffusional processes is represented by the gradient of an "energy-transfer potential". By utilizing kinetic theory, this gradient is found to be equal to the enthalpy gradient multiplied by the ratio of gas viscosity to an effective Prandtl number (the latter has the Schmidt number contained in its definition). The energy equation then assumes the same form as obtained when heat conduction is the only diffusional process present. Hence, it is concluded that the heat transfer with dissociation is primarily a function of the enthalpy difference across the boundary layer, and that the maximum heat transfer occurs when dissociation equilibrium is attained at the wall.

R. Siegel, USA

**555. DeGroff, H. M., Comments on viscous heating,** *J. aero. Sci.* **23,** 10, 978–979 (Readers' Forum), Oct. 1956.

Problem analyzed is the steady laminar flow of a viscous heat-conducting perfect gas between two infinite horizontal planes. Lower plane is fixed; upper plane moves parallel to itself. Both planes are maintained at same fixed temperature. Prandtl number and ratio of specific heats are assumed constant. Purpose of note is to concisely summarize Dr. S. Goldstein's unpublished analysis of this problem and to compare Dr. Goldsteins' results with author's previous results. Results given are the relation between velocity and temperature for any viscosity variation with temperature, and the velocity profile and temperature profile for viscosity proportional to temperature. Pressure distribution between planes is also obtained. Ratio of skin friction to heat transfer is the same whether viscosity and heat conductivity vary directly as temperature or are constant.

N. Tetervin, USA

**556. Chauvin, L. T., and deMoraes, C. A., Correlation of supersonic convective heat-transfer coefficients from measurements of the skin temperature of a parabolic body of revolution (NACA RM-10),** *NACA TN* 3623, 38 pp., Mar. 1956.

Local coefficients of convective heat transfer have been evaluated from skin temperatures measured along the body of an NACA research missile designated the RM-10. The general shape of the body was a parabola of revolution of fineness ratio 12.2. Heat-transfer data are presented for a Mach number range of 1.02 to 2.48 and for a Reynolds number range of $3.18 \times 10^6$ to $163.85 \times 10^6$ based on the axial distance from the nose to the point at which temperature measurements were made.

Results from the data obtained are presented as the product of Nusselt number $N_{Nu}$ and the $-1/3$ power of Prandtl number $N_{Pr}$ against Reynolds number $R$ based on axial distance to the station where the measurements were made. The equation for heat transfer for a turbulent boundary layer on a flat plate in subsonic flow ($N_{Nu} N_{Pr}^{-1/3} = 0.0296\ R^{0.8}$) is shown to be in good agreement with the test results when the heat-transfer parameters are based on the temperature just outside the boundary layer. Basing the correlation of heat-transfer parameters on air properties calculated at the wall temperature gave results that were in good agreement with the equation for convective heat transfer for cones in a supersonic flow $N_{Nu} N_{Pr}^{-1/3} = 0.034\ R^{0.8}$. Heat-transfer coefficients from the V-2 tests correlated on a Nusselt, Prandtl, and Reynolds number relation gave values that were approximately 15% lower than the results obtained on the RM-10 research missile, for conditions where the parameters were based on the temperature just outside the boundary layer, or on the wall temperature. Values of recovery factor were obtained for the stations at which temperature measurements were made and are in agreement with theoretical values of recovery factors for a flat plate.

From authors' summary

**557. Yuge, T., Theory of heat transfer of spheres in uniform stream at low Reynolds numbers,** *Rep. Inst. high Speed Mech., Tohôku Univ.* (*B*) no. 6, 143–151, 1956.

A series solution was obtained of the convection equation for forced flow over a sphere using the velocity distribution of Stokes, which is valid only for small values of Reynolds modulus. The temperature distribution, local and average Nusselt moduli are calculated.

D. C. Hamilton, USA

**558. Yuge, T., Theory of distributions of the coefficients of heat transfer of two-dimensional bodies of various shapes,** *Rep. Inst. high Speed Mech., Tohôku Univ.* (*B*) no. 6, 153–173, 1956.

The local value of Nusselt modulus was calculated for the case of the laminar boundary layer along the surface of a two-dimensional body of arbitrary shape placed in the uniform velocity field of an incompressible fluid, the properties of which are constant except for the thermal diffusivity and kinematic viscosity, which are taken to be linear functions of temperature. The series solution of the convection equation was found to agree satisfactorily with experimental values for a circular cylinder.

D. C. Hamilton, USA

**559. Spengos, A. C., and Cermak, J. E., Heat transfer by forced convection from a horizontal flat plate into a turbulent boundary layer,** 1956 Heat Transfer and Fluid Mechanics Institute, Stanford, Cal., Prepr. no. 7, 16 pp.

Authors have measured mean velocity and mean temperature profiles, with heat input to a horizontal flat plate with a turbulent boundary layer developed along the length of the plate.

Data are compared with theoretical predictions of Davies [AMR **9,** Rev. 1169] for the mean velocity and temperature profiles and for a slightly modified von Karman correlation of the Stanton number versus a modified Peclet number $[(2/f)^{1/2} RePr]$. Heating of the plate has negligible effect on the mean velocity profile, an experimental profile needed in the Davies formulation for mean temperature. Heating of the plate markedly affects the eddy diffusivity for momentum ($\epsilon$), another experimental profile used in the Davies formulation. The ratio ($\lambda$) of eddy diffusivities, heat ($\epsilon_H$) to momentum ($\epsilon$), both determined experimentally, is found to vary from $\lambda = 10$ near the plate surface to a value $\lambda \ll 5$ near the free-stream edge of the boundary. The Davies formulation for the mean temperature profile compares well with experiment if the isothermal value of $\epsilon$ and a value of the eddy-diffusivity ratio ($\epsilon_H/\epsilon$) near one ($\lambda \approx 1$) are used. Authors believe the discrepancy in the value of $\lambda$ required for Davies' prediction to check experiment can be resolved by a more accurate determination of $\epsilon_H$ and a consideration of presently neglected buoyancy effects in the boundary layer.

A check of the Stanton –$(2/f)^{1/2}$ Peclet correlation with the experimental data is included. E. V. Somers, USA

**560. Beckers, H. L., ter Haar, L. W., Tjoan, L. T., Merk, H. J., Prins, J. A., and Schenk, J., Heat transfer at very low Grashof and Reynolds numbers,** *Appl. sci. Res.* (A) **6**, 1, 82–84 (Letter to the Editor), 1956.

**561. Jarre, G., Heat, mass, and momentum transfer between a vapor-laden gas stream and a wetted surface** (in Italian), *Monogr. Lab. Aero. Politecn. Torino* **90**, 364, 21 pp., 1955–56.

Having established, with simplifying assumptions, the fluid field equations for velocity, concentration, and enthalpy in a mixed gas-vapor stream, the heat, mass and momentum transfer between such a stream and a wetted surface, formed by the liquid or solid phase, is evaluated and discussed.

From author's summary by M. J. Goglia, USA

**562. Fieber, H., The unsteady temperature field in regions moving in one direction** (in German), *Öst. Ing.-Arch.* **10**, 2/3, 155–160, 1956.

Author considers the determination of the temperature distribution $T(x,y,z,t)$ in a finite region moving with constant velocity $v$ in one direction ($z$ axis), being initially $T=0$ and $T = T_0$ at $z=0$ and $aT_z + bT=0$ at $z=vt$, ($a,b,T_0$ constants). The solution of problem ($P$,I) is obtained by transformation in other problem ($P$,II) for the semi-infinite region, with an instantaneous point source at $z=vt$ of unknown strength $q(x,y,z)$ [See Sneddon, "Fourier transforms," 1951, p. 202]. This strength will be evaluated so that the equivalence of ($P$,I) and ($P$,II) may be assured. The solution of ($P$,II) is obtained by the finite Fourier transform, and unknown strength $q$ by a Volterra integral equation.

G. Sestini, Italy

**563. Dennis, S. C. R., and Poots, G., An approximate treatment of forced heat convection in laminar flow between parallel plates,** *Appl. sci. Res.* (A) **5**, 6, 453–457, 1956.

The problem of heat transfer in the case of Poiseuille flow between parallel plates has been previously treated with great elaboration by Prins, Mulder and Schenk, [AMR **4**, Rev. 3061] and by van der Does de Bye and Schenk, [AMR **5**, Rev. 548]. Authors now propose to solve the same problem by Rayleigh's principle. For different wall conditions, the approximate calculations are shown to be in close agreement with the known accurate results.

Y. H. Kuo, China

**564. Pfennigwerth, P. L., and Baker, M., Intermittent heating and cooling of buildings,** *Heat. Pip. Air Condit.* **28**, 6, 113–119, June 1956.

A discussion of the problems associated with the intermittent heating and cooling of buildings is presented together with an explanation of the method of finite differences as a suitable technique for analysis. Equations are developed for applying the method to intermittent heating and cooling problems. Certain assumptions are introduced in the development, and pilot experiments were conducted for validation. The principal contribution of this presentation is the establishment of certain boundary conditions which enables use of the method of finite differences to determine the load requirements of intermittently heated or cooled buildings. From authors' summary

**565. Lane, A. M., and Stern, S., Application of superheated-vapor atmospheres to drying,** *Mech. Engng., N. Y.* **78**, 5, 423–426, May 1956.

The unique advantages of using superheated vapors, especially superheated steam, as a drying medium have long been recognized; however, early attempts at commercial application were hampered by unavailability of equipment suitable for superheated-vapor operation. Much of the first drying equipment operated batchwise. Batchwise operation is inherently unsatisfactory for superheated-vapor drying because of start-up and shut-down losses. Much of the superheated-vapor drying was carried out under pressure, and equipment costs were thereby increased. As a consequence, superheated-vapor drying did not gain wide acceptance.

Until comparatively recently, no attempt was made to study the superheated-vapor drying operation and to obtain fundamental heat-transfer rate data which would be useful for the systematic development and design of such drying systems. Wenzel and White presented experimental data on heat-transfer and evaporation rates for superheated steam at several pressures. Chu, Lane, and Conklin presented similar data for steam, n-butanol, and benzene at atmospheric pressure. At the present time additional studies are being made and pilot-plant equipment is in operation. Production-size equipment is being planned. A typical superheater-vapor drier arrangement is shown.

[See AMR **9**, Rev. 1618] From authors' summary

**566. Somers, E. V., Theoretical considerations of combined thermal and mass transfer from a vertical flat plate,** *J. appl. Mech.* **23**, 2, 295–301, June 1956.

See AMR **9**, Rev. 1990.

**567. Boon, E. F., Introduction to the general discussion on coolers and condensers** (in Dutch), *Ingenieur* **68**, 27, Ch. 15–Ch. 26, July 1956.

A simplified treatment of heat transfer in coolers and condensers is given, using the film concept and the heat-flow resistance, the inverse of the heat-transfer coefficient. Five factors in design are discussed: heat transfer, pressure drop, materials of construction, type of construction, and operation. It is possible to find the optimal condensor by combining these factors and determining minimum operating cost by graphical methods.

From author's summary

**568. Havill, C. D., and Rolls, L. S., A sonic-flow orifice probe for the in-flight measurement of temperature profiles of a jet engine exhaust with afterburning,** *NACA TN* 3714, 18 pp., May 1956.

A probe is described for measurement of stagnation temperatures in high-temperature gas streams. The unit consists of two sonic-flow orifices in series, two total pressure tubes, one thermocouple, and static pressure holes. The gas is drawn through the orifices by a vacuum pump and the total pressure preceding each orifice is measured. The gas temperature at the downstream orifice is given by the thermocouple. The gas is cooled between the two orifices thus placing the thermocouple in a relatively cool region and avoiding corrections. Operation is based on mass flow, and from the above measurements the stagnation temperature preceding the first orifice can be calculated. Calibration of effective orifice area ratio is required.

The characteristic time lag of the system was 0.045 seconds with a measurement uncertainty of 3 to 5%. The probe was used to measure temperature and pressure profiles in a jet engine exhaust during flight. Typical test data included temperatures of 400 to 3800 R. C. R. St. Clair, USA

**569. Corey, R. C., Measurement of gas temperatures with thermocouples,** *Combustion* **28**, 4, 47–55, Oct. 1956.

## Combustion

(See also Rev. 586)

**570. Wong, E. L., Some effects of small-scale flow disturbance on nozzle-burner flames,** *NACA TN* 3765, 19 pp., Sept. 1956.

The work of Wong has been anticipated by many years by the designers of laboratory-type Bunsen burners. These designers

have succeeded in producing marked shortening of flame. Such burners are available from laboratory equipment firms.

Wong worked with a gas; jets burn liquid fuel. Burning characteristics are poles apart. Liquid must be converted to gas prior to mixture with air for burning. This function is endothermic. It is continuing all through the oil flame in spray-burning. Effect of turbulence due to admission of air to oil flame is well known. Such turbulence can be obtained in many ways, all of which are well known to those versed in the art.

Wong, in keeping with other work in pure science, disregards the effect of temperature in governing the velocity of combustion reactions to obtain more rapid or more complete burning of fuels.

While Wong's work is well done and beautifully reported, we see no engineering significance in his work.

R. Reed, USA

**571. Bahn, G. S., Reliability of combustion efficiency evaluation for jet propulsion based upon aerodynamic measurement of combustion temperature,** *Jet Propulsion* **26,** 10 (part 1), 861–866, 887, Oct. 1956.

Paper discusses the random errors in combustion efficiency (temperature rise or fuel/air ratio basis) evaluated from measurements of fuel and air mass flows, gas properties, nozzle pressures, and the continuity equation. Author concludes that probable error in efficiency is ±5%, chief contributor being measurement of nozzle pressures. D. B. Spalding, England

**572. Schriesheim, A., Method for the controlled burning of combustible materials and analyses of the combustion gases,** *J. Res. nat. Bur. Stands.* **57,** 4, 245–249, Oct. 1956.

A method is described to burn a given quantity of a combustible material in a fixed amount of air at a selected initial temperature. Analyses of most of the gaseous combustion products were made quickly and comprehensively by means of a mass spectrometer. Hydrogen chloride was not detected with the mass spectrometer because of its adsorption upon the walls of the glass combustion chamber. The concentration of this gas was determined by titrating a water wash of the combustion chamber with a standard silver nitrate solution. Carbon monoxide when present in concentrations below 1000 parts per million was determined by an indicator method, and when present in concentrations above 1000 parts per million was determined by the mass spectrometer. Several organic coatings of different chemical composition were burned in a combustion space initially maintained at three temperatures. The lowest temperature (250 C) produced the smallest variety of combustion gases, whereas the highest temperature (550 C) produced the largest variety.

From author's summary

**573. Kissinger, H. E., Variation of peak temperature with heating rate in differential thermal analysis,** *J. Res. nat. Bur. Stands.* **57,** 4, 217–221, Oct. 1956.

In differential thermal analysis, the temperature at which the maximum deflection is observed varies with heating rate for certain types of reactions. An expression can be derived relating this variation with the kinetics of the reaction. By making a number of differential thermal patterns at different heating rates, the kinetic constants can be obtained directly from the differential thermal data.

Measurements of the variation of peak temperature with heating rate have been made for several minerals of the kaolin group, the values of the kinetic constants determined, and these values compared with corresponding values obtained for both the same samples and similar material by conventional isothermal techniques. Some factors affecting the results are discussed.

From author's summary

**574. Barnett, H. C., and Hibbard, R. R., Properties of aircraft fuels,** *NACA TN* 3276, 152 pp., Aug. 1956.

Since publication of *NACA RM*'s E53A21 and E53116, interest in fuel properties at high temperature has increased. This interest is prompted by problems arising from the possible use of fuel as a heat sink in supersonic aircraft now being designed. For this reason, the two previous publications have been combined, and wherever possible the data have been extended to cover properties of fuels up to temperatures as high as 400 F. Recently available data on properties not included in the original compilations have been introduced in the present report, and some of the existing data on fuel characteristics have been revised to improve accuracy and utility. From authors' summary

**575. Anderson, D. R., and Watson, W. R., Soot ignition temperature measurement,** *Combustion* **28,** 4, 43–46, Oct. 1956.

## Acoustics

(See also Rev. 544)

**576. Meecham, W. C., Fourier transform method for the treatment of the problem of the reflection of radiation from irregular surfaces,** *J. acoust. Soc. Amer.* **28,** 3, 370–377, May 1956.

The integral equation for the wave reflected by an irregular free surface (i.e., pressure release) is treated by a perturbation method. The kernel of the equation, the free space Green's function involving the separation of two points on the surface, is approximated by the analogous function of the separation projected on the mean surface; the difference between the two is treated as a perturbation, and the iterated equations are solved by Fourier transforms. The leading terms suffice provided that the square of the slope of the reflecting surface is small, and the incident wave length is not small compared to the displacement of the surface from its mean. The results are specialized to periodic surfaces, and applied to the simple sinusoid. Graphs of the intensities calculated for the sinusoid are shown to be in better agreement with the experimental results of LaCasce and Tamarkin, than the analogous graphs of Rayleigh's approximation.

V. Twersky, USA

**577. Cremer, L., The transmission impedance of a cylindrical shell** (in German), *Acustica* **5,** 5, 245–256, 1955.

The transmission impedance of a cylindrical shell is given by the mass reactance, the reactance of stiffness against bending, and a reactance due to the tension of the shell. This stiffness reactance against tension is given as a function of the incidence angle of the waves, as well as inversely proportional to the frequency. The transmission loss and the stiffness become infinite when the velocity of the wave which is propagated the length of the cylinder is equal to the velocity of the longitudinal wave or to the velocity of the shear waves. This phenomenon occurs near perpendicular incidence. Outside of this region, the tension stiffness is shown to be proportional to the fourth power of the sine of the angle between the plane of incidence and the plane perpendicular to the axis. For high frequencies, the mass reactance and the stiffness reactance against bending may compensate each other. For shells with small diameter compared to the wave length, mainly axial motions are to be expected within the shell. A. H. Hausrath, USA

**578. Powell, A., A note on the sound from weak disturbances of a normal shock wave,** *Aero. Res. Counc. Lond. curr. Pap.* no. 194, 8 pp. + 6 figs., 1955.

Author studies interaction of sound waves and temperature inhomogeneities with a shock wave. Analysis deals with the one-dimensional case associated with normal incidence. Results

are somewhat superseded by recent two-dimensional analyses revealing the interesting effect of the angle of incidence (see J. Brillouin, AMR **9**, Rev. 2390 and bibliography cited therein). Problem bears on jet noise and shock-wave detection.

M. C. Junger, USA

**579. Fogle, R. E. L., and Withington, H. W., An airplane manufacturer's progress with noise suppression devices,** *SAE Trans.* **63,** 303–307, 1955.

**580. Tyler, J. M., and Perry, E.C., Jet noise,** *SAE Trans.* **63,** 308–320, 1955.

## Ballistics, Detonics (Explosions)

(See also Revs. 543, 596)

**Book—581. Sutton, G. P., Rocket propulsion elements,** 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, x + 483 pp. $10.25.

In its second edition this book has been expanded in size by about 65%. Most of the additional material concerns solid-propellant rocket motors which were mentioned only briefly in the first edition. Author appears to have made this concession rather reluctantly since he states in the preface that liquid-propellant "fields of application are of greater general interest than those of solid-propellant units." Most advocates of solid propellants would take issue with this statement, as well as with author's tabulation of the relative merits of solids and liquids. A chapter on heat transfer has also been added, but the book will still be of value primarily to those persons interested in entering the field of liquid-propellant rocket-motor design, development, and testing. A fairly comprehensive unclassified bibliography which parallels the chapter organization occupies the final 46 pages.

In the light of current events the section on space travel is interesting; the energy required to escape from earth is given as $8.74 \times 10^8$ Btu per slug (only about twice that required for a satellite), but the author believes "the problems of navigation, communication, guidance, take-off, and landing need further investigation."

R. M. Stewart, USA

**582. Leitmann, G., A calculus of variations solution of Goddard's problem,** *Astronaut. Acta* **2,** 2, 55–62, 1956.

Refined approach evaluating fundamental relations for a minimum initial rocket mass is based on R. H. Goddard's idealized rocket theory. Lagrangian multipliers and Euler-Lagrangian equation are used in solution of an optimum thrust programming problem. The entire method is well defined and useful tool for applied analysis of parameters for maximum altitude of vertical rocket trajectory.

C. R. Bell, USA

**583. Ehricke, K. A., The satelloid,** *Astronaut. Acta* **2,** 2, 63–100, 1956.

Comprehensive paper defines requirements and utilization of a powered orbiting vehicle, capable of operating at an altitude between 68 to 87 miles (110 to 140 km). This is the region of lower ionosphere, the exploration of which is essential for solution of re-entry problems. It is too low an altitude for a present satellite concept (nonpowered orbiting) and it is also above the steady ceiling capability of present aerodynamic rocket glider configurations. Satelloid would be applicable to global atmospheric research, investigations of extra-terrestrial atmospheres, evaluation of future propulsion systems, novel maneuvers, and adaptation studies for human integration to space flight.

Competent outline of flight performance analysis is aimed to prove the feasibility of relatively long stay time in orbit. This is further documented by thorough evaluation of satelloid aerodynamics and theoretical study of anticipated skin temperatures of the satelloid. Final approach to solution by numerical analysis of the outlined relationships is also included, together with numerous graphs and correlations with available experimental data.

C. R. Bell, USA

**584. Heyda, J. F., An elementary derivation of the formula for the windage jump of a spinning shell,** *J. Franklin Inst.* **261,** 6, 615–619, June 1956.

Starting from fundamental differential equations of motion of a spinning shell which define the particle and the actual trajectory of the center of gravity of the shell, and from the formula for angular velocity of a point on the axis of the shell, author derives immediately the formula for the windage jump. The entire system of equations, employed by Fowler, Gallop, Lock and Richmond, which served as a basis in the work of Sterne, is not used here by the author. From the derived formula it follows that the actual trajectory lies below the particle trajectory.

J. Marinkovic, Yugoslavia

**585. Casci, C., On the performance of a missile** (in Italian), *Aerotecnica* **35,** 6, 291–297, December 1955.

The performance of a missile is influenced by the air drag, while that of a rocket engine is independent therefrom. The air drag can be neglected at altitudes over 60 km; on the contrary, at altitudes of about 10–30 km it is very important and the propellant mass flow must be increased in order to attain supersonic speeds. The best operational conditions for air-to-air and ground-to-air missiles can be deduced by using some diagrams as function of the propellant mass flow and the diameter of the missile body.

From author's summary

**586. Grabowski, G., Developments in explosion- and fire-suppression techniques,** *SAE Trans.* **63,** 803–808, 1955.

## Soil Mechanics, Seepage

(See also Rev. 473)

**587. De Josselin De Jong, G., What happens in the soil during pile-driving** (in Dutch), *Ingenieur* **68,** 25, 77–90, June 1956.

Author presents a study of the propagation of the pressure in rods under dynamic loading conditions. He finds a differential equation presenting the structure found in the study of water-hammer in pipes and uses the graphical method of characteristics of Massau to determine stress and velocity. Application to a sample of dry sand gives regions of permanent deformation and dissipation of energy into friction. Penetration of the energy into the interior of the sample is deeper for long duration of impact. Experiments confirm the theoretical results.

In the second part of his paper, author studies the action of dynamic loads on sand saturated with water by separating stresses and velocities of the two phases; water supports nearly total dilatation stress. He also shows that, for high frequencies, the load mostly affects the water stresses.

L. J. Tison, Belgium

**588. Vucetic, D., Ideal soil materials for the construction of earth dams** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 2, 177–186, Feb. 1956.

Soils with relatively large angles of internal friction and low permeability are considered to be the most suitable for construction of earth dams. They must contain percentage of sand and gravel to insure satisfactory shear resistance. Results of experiments with various mixtures of sand and silty clay are presented graphically. Cohesion increases with the percentage of silty clay. Four examples are thoroughly investigated, in which

the advantages of the best soil composition were not used, although the available material would have permitted it. Resulting losses amounted to 10–24%. Furthermore, the construction of the dam could have been considerably simpler.

Reference is made to work by Terzaghi, Jáky, Bogoslovski, Vasilyef, Verdeyen, Caquot, Kérisel, Meyer-Peter, Kollbrunner, Peferman, and Agatz. J. J. Polivka, USA

589. **Maksimovic, L., The need for a more precise classification of soils** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 3, 369–371, Mar. 1956.

Yugoslav and other standards classify soils in very few categories, considering only geologic characteristics, grain size, etc. In this way it is possible, e.g., that rock of high resistance could be put in category of weaker rocks with lower bearing capacity. In accordance with a suggestion of N.D. Averin, author specifies 16 categories of soil on the basis of following properties: specific weight, resistance in compression and time necessary to drill a hole 1 meter deep (3.28 ft) with specified equipment. Two latter properties are specified for categories 6 to 16 with compressive strength from 3 to 35 kips sq in. requiring drilling time from 2 to 60 minutes. Compressive strength of Yugoslav rocks varies from 15 to 46 k/ sq. in.

Also, German and Russian classifications are discussed.
J. J. Polivka, USA

590. **Kostic, V., Contribution to practical determination of maximum axial forces in piles supporting foundation slabs** (in Serbian), *Nasě Gradevinarstve, Beograd* **10,** 4, 493–498, Apr. 1956.

Method of influence lines for each individual pile is used. Culmann's method is used for batter piles. It is assumed that piles having the same inclination carry equal loads. Axial forces are proportional to the statical moment about the neutral axis of each pile. Numerical examples explain the presented method.
J. J. Polivka, USA

591. **Kostic, V., Contribution to practical and more economical design of timber sheeting in foundation work** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 5, 678–681, May 1956.

It is shown by practical examples that up to approximately 20% saving can be obtained in designing sheet-pile cofferdams if the ground soil is permeable, or if the water in cofferdam is pumped out. J. J. Polivka, USA

592. **Jovanovic, R., Geological investigation and engineering research on the railroad track Sarajev-Ploče** (in Serbian), *Naše Gradevinarstvo, Beograd* **10,** 5, 681–684, May 1956.

Four alternate lines have been investigated and studied as to geological conditions and economy of construction. Direction of the railroad, headed by Prof. S. Miovčić, engaged several groups of experts in various fields for assistance, such as "Geoistraživanja" in Zagreb, department of geology, University in Sarajevo, and others. J. J. Polivka, USA

593. **Shestakov, V. M., Seepage forces in open cuts** (in Russian), *Gidrotekh. Stroit.* **22,** 10, 21–25, 1953.

In a cut of trapezoidal section, made in a layer of homogeneous porous material resting on an impervious stratum, the water lever is lowered with velocity $v$. Problem considered (2-dim.) is to find seepage line and its intercept with discharge face. In case I, mere drainage is present; in case II, a line of deep wells is operating at some distance from edge of cut.

For several geometrical configurations experimental investigations show that problem can be reduced to the equation

$$(h^2)_t = kh/\mu \cdot (h^2)_{xx}. \qquad [1]$$

For case I region is divided in two by vertical $C$ through edge of cut. For upstream portion equation [1] is reduced (Bagrov-Verigin) to the heat equation, assuming constant the factor of the derivative in $x$. Solution is immediate. For downstream portion, with the sloping face, use is made of correspondence method. An approximate value $\bar{h}(x,t)$ is taken for $h$, and set into left side of [1], which is approximated to $\bar{h}_t = k/2\mu \cdot (h^2)_{xx}$, and integrated. If $\bar{h} = h$, solution is exact. If equality holds only at a few points, solution $h$ is approximate. Procedure can be repeated, but equality at two points is sufficient for practical purposes, as shown by applications.

Method applied is case I yields intercepts of seepage line with sloping face and with $C$. Expressions based on Pavlovski discharge-function $\varphi$ are given for three cases corresponding to various depths of impervious bed. In case II is determined the relation between draw-down velocity and well discharge with the condition that hydraulic gradient be zero at the discharge face. An example of computation illustrates this procedure.
G. H. Beguin, Switzerland

## Geophysics, Meteorology, Oceanography

(See also Rev. 509)

**Book—594. Golding, E. W., The generation of electricity by wind power,** New York, Philosophical Library, Inc., 1956, xvi + 318 pp. $12.

The possibilities of an inexhaustible source of wind energy for generation of electricity are being considered seriously in underdeveloped parts of the world. It is a pleasure to have this book by a well-trained specialist. The work embraces the entire field of generation of electricity by wind power, i.e., chapters on the history of windmills, estimation of energy obtainable from the wind, wind characteristics and distribution, wind power sites, wind surveys, wind flow over hills, the measurement of wind velocity, wind structure and its determination, wind data and energy estimation, the testing of wind-driven a-c generators, wind-driven machines, propeller-type windmills, plants for isolated premises and small communities, the economy of wind-power generation, construction costs for large wind-driven generators, the relationship of wind power to other power sources, research and development, and international cooperation. Two appendixes of selected bibliography on surface wind data and on glossary of terms used in the study of wind power are so indispensable and helpful to readers.

Reviewer believes author should consult *Meteorological Abstracts and Bibliography* **5,** 10, 1187–1230, October 1954 (A selective annotated bibliography on industrial meteorology). Reviewer does not think "Japanese windmills in use B. C. 2000" (page 18). H. Arakawa, Japan

595. **Frenkiel, F. N., and Katz, I., Studies of small-scale turbulent diffusion in the atmosphere,** *J. Meteor.* **13,** 4, 388–394, Aug. 1956.

The results of a measurement program involving the change in size of gun-powder smoke puffs are presented so as to give values of the root-mean-square value of the turbulent velocity, the intensity of turbulence, and the integrated concentration ratio. The observations were made over water by the Naval Research Laboratory at Tilghman Island, Maryland on 27 and 28 February, 1950, by suspending a smoke puff generator below a tethered baloon at altitudes of several hundred feet above the water. Two triangulated motion-picture cameras were employed to determine the position and size of the smoke puff. The pictures were analyzed so as to remove the effects of large-scale gusts and mean atmos-

pheric motion, leaving only the turbulent growth of the puffs by small-scale atmospheric eddies.

Assuming homogeneous and isotropic turbulence, authors obtain a linear equation in which $a^2/t^2$ ($a^2 = x^2 + y^2$ where $x^2 = y^2$ are the variances of the mean concentration along the coordinate axes, and $t$ is the dispersion time) is plotted as a function of $\ln t^2$. The slopes and intercepts of this plot are used to evaluate the pertinent diffusion and turbulence parameters.

Values obtained are shown to be in reasonable agreement with the results of earlier studies ranging from those of smoke puffs in the stratosphere to soap bubbles in a wind tunnel. The general approach was that based on a statistical model of turbulence in which one utilizes a correlation function in seeking the functional form of the diffusion process and is valid for small dispersion times. An alternative method for large dispersion times known as the Fickian technique involves a direct solution of the differential equations, assuming a constant coefficient of eddy diffusion. Authors conclude that smoke puffs are a versatile and simple tool for the study of atmospheric diffusion with particular emphasis on their use in air-pollution research. J. R. Gerhardt, USA

**596. Tolefson, H. B., An investigation of vertical-wind-shear intensities from balloon soundings for application to airplane- and missile-response problems,** *NACA TN* 3732, 33 pp., July 1956.

An analysis was made of the daily upper-wind soundings obtained from one station for a period of one year in an attempt to obtain measurements of the vertical wind shear in a form applicable to airplane- and missile-response problems. On the basis of the variation with altitude of the wind speed and direction indicated by the soundings, significant wind-shear layers were resolved into two cross components, the so-called longitudinal and normal shears, and their intensities and thicknesses determined. These data are summarized in the form of frequency distributions of the shear intensity and the thickness of the shear layers for different altitude ranges and seasons of the year.

The results indicate maximum longitudinal shear intensities of about 100 mps/kilometer occurring at altitudes of 10 to 15 kilometers during the winter and spring months and maximum normal shear intensities of about 60 mps/kilometer. Only about 10% of the shear layers were greater than 1 kilometer in thickness. The application of these results on the wind-shear intensities to the calculation of the normal response of a missile in vertical flight at two different altitudes is also considered briefly.

From author's summary

**597. Saffman, P. G., and Turner, J. S., On the collision of drops in turbulent clouds,** *J. fluid Mech.* **1,** 1, 16–30, May 1956.

In this theory, drops of equal size are considered which are much smaller than the small eddies of the turbulence. Therefore the collision rates depend only on the dimensions of the drops, the rate of energy dissipation, and the kinematic viscosity. It is assumed that the collision efficiency for nearly equal drops is unity and a mathematical expression is derived for the collision rate as a function of the spatial variations of turbulent velocity. Integration of this expression shows how an initially uniform distribution will change because of the collisions. An approximate calculation is then made to take into account also the collisions occurring between drops of different inertia owing to gravity and turbulent accelerations.

The results are applied to small drops in atmospheric clouds to test the importance of turbulence in initiating rainfall. Estimates are made for the rate of energy dissipation for typical conditions and, with these, the initial rates of collision are calculated, and the rate of production of large drop is derived. It is concluded that the effects of turbulence in layer-type clouds should be small, but that in cumulus clouds turbulence would broaden the drop-size distribution, owing to the spatial velocity variations. In heterogeneous clouds the collision rates are increased, and the inertia effects of the drop become predominant. The effect of turbulence in causing collisions between unequal drops becomes comparable with that of gravity when the rate of energy dissipation is about 2000 $cm^2/sec^{-3}$. K. J. De Juhasz, Germany

**598. Weisner, A. G., Measurement of winds at elevations of 30 to 80 kilometers by the rocket-grenade experiment** *J. Meteor.* **13,** 1, 30–39, Feb. 1956.

Thirty-two values of wind velocity between 30 and 80 kilometers have been obtained from six Aerobee rocket flights made at night at White Sands Proving Ground, New Mexico (32°N), between July 1950 and November 1951. The average wind velocity in a horizontal layer at a particular altitude was determined from the effect of the wind on a sound wave traveling downward through the layer. The sources of the sound waves were grenades, ejected and exploded along the upward path of the rocket. The positions of the grenades, the travel times of the sound waves to a point of the ground almost directly underneath the grenades, and the angles of arrival of the waves at the ground are the data required for the calculations.

The wind directions were found to be easterly in summer and westerly in autumn and winter. The wind speeds were a maximum at about 55 km, the largest measured speed having been 104 m/s.

From author's summary

## Lubrication; Bearings; Wear

(See also Revs. 382, 447)

**599. Kreisle, L. F., Very short journal-bearing hydrodynamic performance under conditions approaching marginal lubrication,** *Trans. ASME* **78,** 5, 955–963, July 1956.

Experimental data are presented for bearings with length-diameter ratios of $\frac{1}{33}$ to $\frac{1}{2}$. Theoretical performance of short journal bearings by several theories is compared with experimental findings. Several nondimensional quantities are found to be useful in predicting and analyzing the performance of short journal bearings.

From author's summary by W. J. Anderson, USA

**600. Archibald, F. R., Load capacity and time relations for squeeze films,** *Trans. ASME* **78,** 1, 29–35, Jan. 1956.

Author studied analytically the problem of squeezing fluid film between two surfaces having a relative normal velocity. Mathematical expressions are obtained for the transient load capacity and the time to change thickness of various film configurations. Results are of interest in the designing of bearings with hydrodynamic lubrication. T. C. Lin, China

**601. Wilcock, D. F., and Booser, E. R., Why bearings fail,** *Prod. Engng.* **27,** 10, 167–182, Oct. 1956.

**602. Dawson, E., Pressure transmission in liquid films,** *J. Franklin Inst.* **262,** 4, 255–263, Oct. 1956.

An analysis is presented pertaining to the delay in reaching static equilibrium in a thin flat film of a very viscous-compressible fluid (dimensions are such that inertia terms are negligible) when the pressure at the film edges is suddenly changed. The results of such an analysis gives a qualitative indication of the time required for lubricants in a thin region to become fully compressed and attain equilibrium pressure with the bulk of the lubricant. In addition to the analysis, some experimental results are presented which indicate qualitatively that the time of pressure transmission in highly confined viscous fluid is measurable and appreciable. The equation developed by the author is also applicable to problems involving "oil cushions" if the term involving the differential change of film thickness is kept. Work on the oil cushion effect

could be extended to include the effect of compressibility as developed by the author.

Reviewer suggests that the author's apparatus might be of some use in studying relaxation effects in very long chain polymers. This paper will be of interest to bearing designers and lubrication specialists in general. R. Wick, USA

## Marine Engineering Problems

(See also Rev. 407)

**Book—603. Rudorff, D. W., Modern marine engineering,** New York, Philosophical Library, Inc., 1956, v + 169 pp. $4.75.

This book is basically a historical survey of the main propulsion power plants of interest to students and those not engaged in the design of this equipment. The presentation is philosophical rather than technical. Material is taken primarily from British references. The scope of the work may be seen from the following list of the pages devoted to each propulsion type: General aspects of propulsion plants, 9 pages; Steam boilers, condensers, steam recuperators, 12 pages; Geared steam turbine drives, 18 pages; Turboelectric propulsion, 20 pages; Diesel engines, 32 pages; Diesel electric propulsion, 19 pages; Gas turbines, 28 pages; Ships' steering gear, 5 pages; Auxiliary machinery, 26 pages.

In general, in each chapter author delineates type details of the plant being discussed, giving the advantages and disadvantages, and illustrates it with comparison of selected vessels using that particular type of power plant. W. E. Hammond, USA

**Book—604. Muckle, W., Modern naval architecture,** New York, Philosophical Library, Inc., 1956, vi + 154 pp. $4.75.

This text presents an outline of the status of practical naval architecture as developed up to the present. Some idea of the contents of the book can be obtained from the chapter headings following the introduction, which itself deals with some of the elementary concepts of the design of ships. Chapter headings: The design of hull form; The propulsion of ships; Speed and power trials; Ship structures; The safety and seaworthiness of ships; Accommodation on board ship and the provision for comfort.

Reviewer believes book would be of value to undergraduate students in that it gives a good picture of what is important in the design of commercial vessels. However, author makes almost no attempt to refer the reader to the scientific literature which has built up considerably in the past decade. The bibliography does refer to standard naval architectural texts and to the transactions of the various naval architectural societies.

J. P. Breslin, USA

**605. Steneroth, E., On the transverse strength of tankers,** *Trans. roy. Inst. Technol. Stockholm* no. 90, 104 pp., 1955.

Methods are discussed for calculating the bending moments in transverse frameworks of ships, taking into account effects of longitudinal continuity on local stiffness of transverse members. Distribution of moment is analyzed by adaptation of Vedeler's methods for gridworks, by standard Hardy Cross procedures, Efsen's primary moment methods and slope-deflection equations. Also investigated are influences of varying moment of inertia of members, shear deflections, and joint displacements. Effective width of plating is taken as equal to spacing of longitudinals and of transverses when computing their respective stiffnesses.

Following a statement of the methods, detailed calculations are performed for a 13,000-ton dead weight tanker whose framework comprises a center tank and two wing tanks with horizontal struts. In the examples, loads are limited to those from liquid contents and buoyancy forces which are uniform lengthwise and at every section in equilibrium with dead weight loading. Thus both the longitudinal variations in load, and hogging or sagging response of the ship are neglected.

By considering a number of cases involving different approximations, author finds that: (1) Effects of shear deformation are of critical importance, sufficient to raise questions concerning validity of simple beam theory for such short, deep members; (2) effects of joint displacement must be included for valid results; (3) longitudinals have effect on bending-moment distribution of transverse members only in center tank; (4) for practical purposes, unsymmetrically loaded wing tanks can be treated by analysis of only one-half section of ship, assuming symmetrical loading. Author claims his slope-deflection-type calculation will save time compared to other methods, and affords simpler treatment of joint displacement and different conditions of loading.

Presentation is sufficiently clear that method may be readily checked. Reviewer believes that the extension suggested by author may not be adequate to accommodate influence on strength of transverse members of torsional as well as bending response of hull girders in a seaway. Also, no treatment is given of the effect of stiffness of transverse members on the longitudinal or torsional ship strength. E. Wenk, USA

**606. Greenspon, J. E., and Wigle, B. M., Probability distribution of wave-induced hull girder stresses for a destroyer escort, based on sea tests of USS Fessenden (der 142),** *David W. Taylor Mod. Basin Rep.* 1020, 9 pp., Apr. 1956.

The statistical-probability distribution of the wave-induced hull girder stresses experienced by a destroyer escort during rough weather service off the North Atlantic coast of the United States was determined from measurements on the main deck amidships. It is shown that the logarithm of the stress may be represented by a normal distribution. The distribution is based on approximately 400,000 strain measurements. From authors' summary

**607. Suhara, J., On the effectiveness of panting stringers and web frames of a ship,** *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **4,** 15, 67–78, Jan. 1956.

Bending of a rectangular grate formed by many equidistant, uniformly loaded beams (frames) and two symmetrical girders (side stringers) is discussed. The method proposed was stated in 1901 by I. G. Boobnov, who tabulated the functions required for practical use.

New in this paper is the attempt to apply this method to the case when two of the beams (web frames) are stiffer than the others. In reviewer's opinion, the example given in the paper shows that, even in this simplest case, considerable numerical work is required, making the method hardly useful in practice.

Author concludes from results of the example that the stiffness of the web frames and stringers as given by Lloyd's rules is not sufficient. The validity of the conclusion is limited by the assumption that both ends of the frames are clamped. Reviewer believes that this assumption is seldom justified.

J. M. Klitchieff, Yugoslavia

**608. Allan, J. F., and Cutland, R. S., The effect of roughness on ship resistance,** *N.E. Cst. Instn. Engrs. Shipb. Trans.* **72,** part 6, 257–278, 1955–56.

Paper deals with the effect on resistance of hull roughnesses, including the effect of structural roughnesses on all-riveted and all-welded shells and of paint and other local roughnesses which frequently occur. It is shown that the calculated reduction in resistance due to the elimination of structural roughnesses is in good agreement with conclusions based on ship trial data.

Paper also shows the marked variation in the effect of structural roughness on large ships compared with small ships and suggests that the modern flush-welded ship with a good paint finish on top of clean bare steel will have a resistance considerably above that of a perfectly smooth surface.

From authors' summary

## Letter to the Editor

**609. Concerning AMR 8 Rev. 2738 (September 1955): Rapier, A. C., A theoretical investigation of the temperature distribution in the metal cutting process.**

The review of my paper "A Theoretical Investigation of the Temperature Distribution in the Metal Cutting Process" [*Brit. J. appl. Phys.* **5**, 400–405] appears to be based on a misunderstanding of the mathematical method used. The crux of the review is contained in the first paragraph, in which the reviewer states that the paper contains a relaxation solution for the temperature distribution of the metal cutting process based on two assumptions, the more important of which is that the component of motion along the shear plane is ignored. The relaxation solution in the paper is in fact a solution to the problem in which both components of motion parallel to and perpendicular to the shear plane are taken into account. The assumptions which are made in the solution are clearly stated in section 3, and do not include either of the two mentioned by the reviewer. The rest of the review follows from this first paragraph. A. C. Rapier, USA

## Books Received for Review

BITTEL, H., Zur Statistik der ferromagnetischen Elementarvorgänge und ihren Einfluss auf das Barkhausenrauschen, Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, no. 251, Köln, Germany, West-deutscher Verlag, 1956, 42 pp.

BODEWIG, E., Matrix calculus, New York, Interscience Publishers, Inc.; Amsterdam, North-Holland Publishing Company, 1956, xi + 334 pp. $7.50.

BULGAKOV, B. B., Kolesanija, Moskva, Gosuparstvennoe Izdatel'stvo Tekhniko Teoreticheskoi Literatury, 1954, 891 pp. $3.20.

CAQUOT, A., and KERISEL, J., Traite de Mecanique Des Sols, 3rd ed., Paris, Gauthier-Villars, 1956, xiv + 558 pp. $11.15.

CARATHEODORY, C., Variationsrechnung und Partielle Differentialgleichungen Erster Ordnung, Band 1, 2nd ed., Leipzig, B. G. Teubner Verlagsgesellschaft, 1956, 171 pp. DM 14.

DIAZ, J. B., and PAYNE, L. E., editors, Proceedings of the conference on differential equations, Univ. of Maryland, Mar. 17–19, 1955, College Park, Md., University of Maryland Book Store, 1956, xxi + 294 pp.

FURRER, W., Raum-Und Bauakustik für Architekten, Basel, Birkhauser Verlag, 1956, 200 pp.

GRAMMEL, R., edited by, Verformung und Fliessen des Festkörpers, Koloquium Madrid, Sept. 26–30, 1955, Internationale Union für Theoretische und Angewandte Mechanik, Berlin, Springer-Verlag, 1956, xii + 324 pp.

KUENE, F., Zusammenfassende Darstellung und Erweiterung des Aequivalenzsatzes für schallnahe Strömung, Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, no. 316, Köln, Germany, Westdeutscher Verlag, 1956, 74 pp.

PANTAZI, A., Opera Matematica, Rumania, Academia Republicii Populare Romine Editura Acad., 1956, 494 pp. Lei 24,20.

ROBINSON, A., and LARUMANN, J. A., Wing theory, (Cambridge Aeronautical Series), New York, Cambridge University Press, 1956, ix + 569 pp. $13.50.

# INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)



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# INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

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